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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LUNAR ROVING VEHICLE SYSTEMS HANDBOOK

APOLLO 17

LRV-3

OCTOBER 2, 1972

PREPARED BY

FLIGHT CONTROL DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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10/2/72

APOLLO

LUNAR ROVING VEHICLE SYSTEMS HANDBOOK

LRV-3

PREFACE

This document prepared by the Flight Control Division, Manned Spacecraft Center, Houston, Texas, with technical assistance by LTV/Kentron Hawaii, Ltd., is being printed with Section 8 to be supplied in a document change package at a later date. Since the Section 9 LM Interface Drawings are taken from Section 13 of the LM Systems Handbook, these drawings will be subject to updating and reprinting as PCN's anytime before the flight as required to reflect the latest changes in the LM Systems Handbook. Information contained within this document represents the lunar roving vehicle systems as of October 2, 1972.

This document is intended for specialized use by the LRV flight controllers in real-time and near-real-time operations. This document, in conjunction with the Boeing Company's LRV Operations Handbook, LS006-003-2H, will provide the LRV flight controllers with a thorough knowledge of the LRV.

Comments regarding this handbook should be directed to the Lunar Surface Experiments Section of the Lunar/Earth Experiments Branch, Flight Control Division. Document Changes providing new basic information or page change updates will be issued as required prior to the flight date.

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APOLLO 17

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OCTOBER 2, 1972

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TABLE OF CONTENTS AND ITEM EFFECTIVITY - OCTOBER 2, 1972 (CONCLUDED)

1 INTRODUCTION

SECTION 1

INTRODUCTION

1.1 LRV ACRONYMS AND ABBREVIATIONS

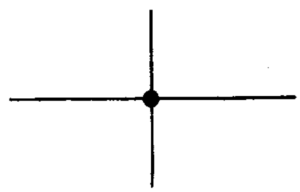
ac	alternating current
Adc	ampere(s) dc
amp	ampere(s)
ant	antenna
assy	assembly
CB	circuit breaker
CDC	control and display console
dc	direct current
DCE	drive control electronics
DGU	directional gyro unit
EP	explosive package
F	fuse, Fahrenheit
fld	field
fwd	forward
gnd	ground
HS	heat sink
inhib	inhibit
insul	insulation
IPI	integrated position indicator
instl	installation
km	kilometer(s)
LCRU	lunar communications relay unit
LM	lunar module
LRV	lunar roving vehicle
max	maximum
mde	mode
MOCR	Mission Operations Control Room
ms	millisecond
MSS	mobility subsystem
mtr	motor
N/A	not applicable
neg	negative
norm	normal
oper	operate
out	output
pct	percent
PLSS	portable life support system
pos	positive
posn	position
pri	primary
PWM	pulse width modulator
pwr	power
ref	reference
reg	regulator
rev	reverse
rly	relay
rst	reset
sci	scientific
sig	signal
snsr	sensor
SPU	signal processing unit
STDN	space tracking and data network
sw	switch
sup	supply
sys	system
T	temperature
temp	temperature
therm	thermal
V	volt(s)
Vac	volt(s) ac
Vdc	volt(s) dc
W	watt(s)
WH	walking hinge

1.2 DRAWING SYMBOL STANDARDS

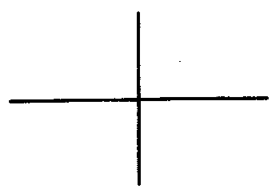
1.2.1 Line Legend

1.2.1.1 Electrical line, power and control.-

A. Electrical connected



B. Electrical crossover



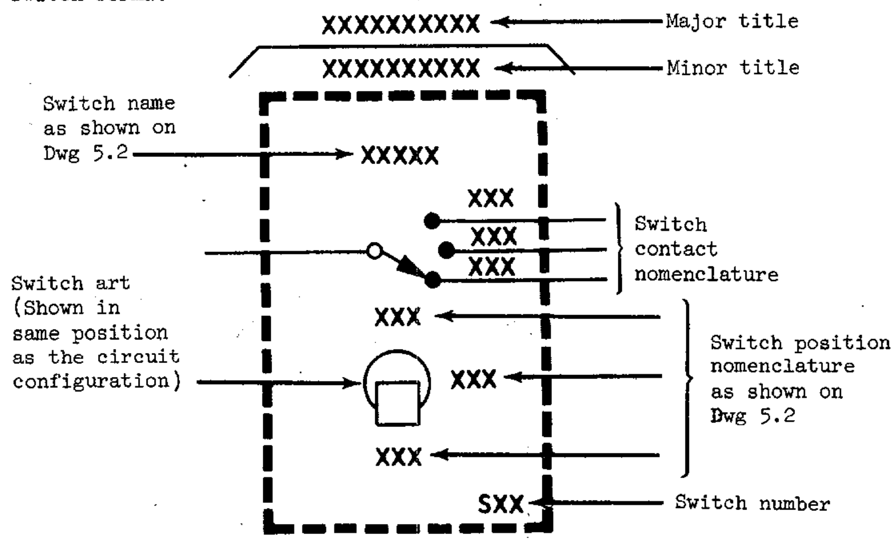
1.2.1.2 Directional flow arrows.-

1.2.1.3 Mechanical linkage.-

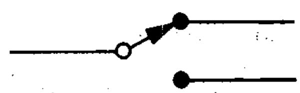
1.2.2 Electrical Symbols

1.2.2.1 Switches.-

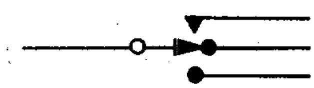
A. Switch format



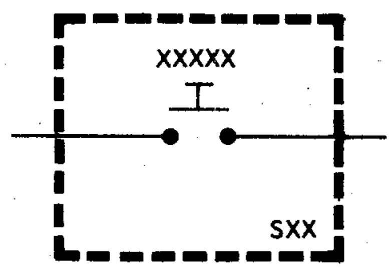
B. Two-position switch



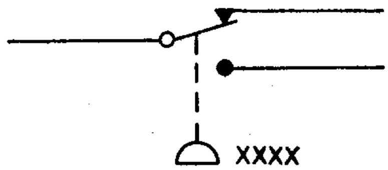
C. Three-position switch



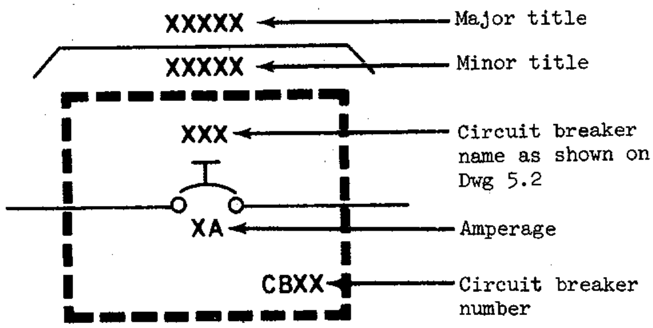
D. Pushbutton switch



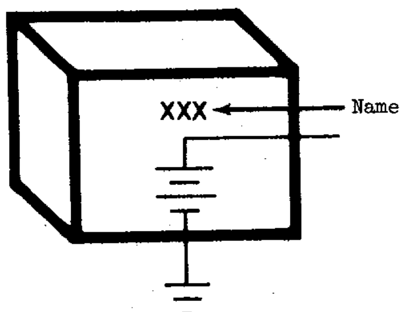
E. Barometric pressure switch



1.2.2.2 Circuit breaker.-

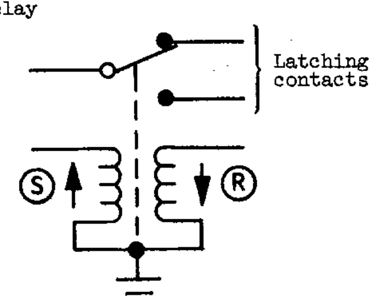


1.2.2.3 Battery.-

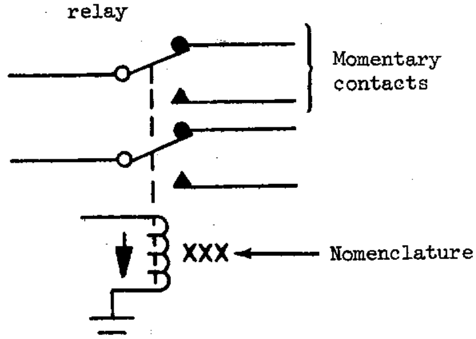


1.2.2.4 Relays.-

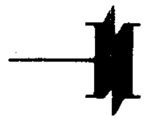
A. Latching relay



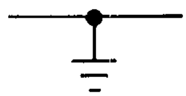
B. Non-latching relay



1.2.2.5 Bus.-



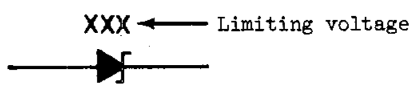
1.2.2.6 System ground.-



1.2.2.7 Diodes.-

A. General

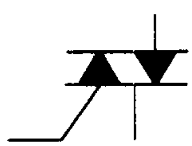
B. Zener



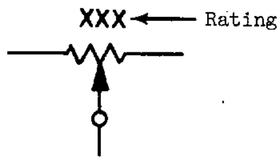
C. Tunnel

D. Control rectifier (SCR)

E. Triac

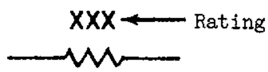


1.2.2.8 Potentiometer.-

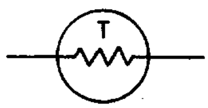


1.2.2.9 Resistors.-

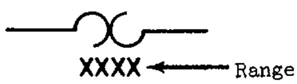
A. Fixed



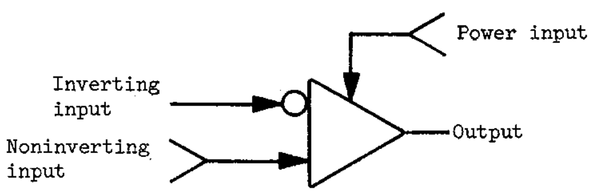
B. Thermistor or resistance thermometer (any element whose sensing resistance varies with temperature regardless of polarity)



1.2.2.10 Thermostat.-

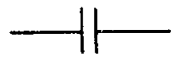


1.2.2.11 Amplifier.-



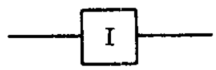
1.2.2.12 Capacitors.-

A. Fixed

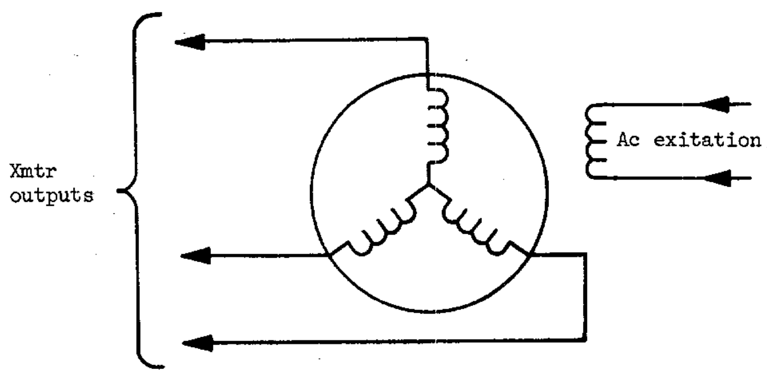


B. Variable

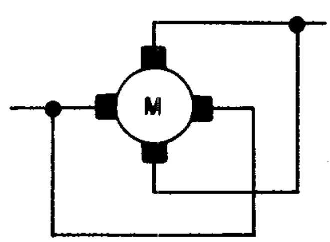
1.2.2.13 Digital inverter.-



1.2.2.14 Synchro transmitter.-

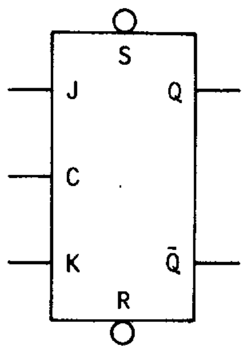


1.2.2.15 Motor.- Redundant brushes

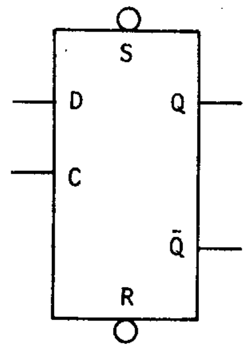


1.2.2.16 Flip-flop.-

A. J-K flip-flop

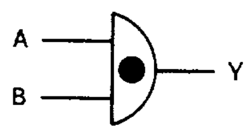


B. D-type edge triggered flip-flop

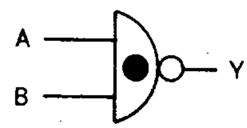


1.2.2.17 Gates.-

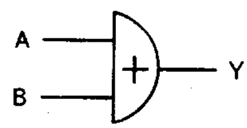
A. And



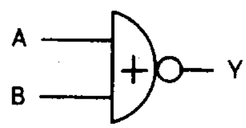
B. Nand



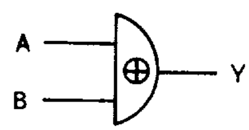
C. Or



D. Nor



E. Exclusive or



Truth table

A	B	Y
1	1	1
1	0	0
0	1	0
0	0	0
1	1	0
1	0	1
0	1	1
0	0	1
1	1	1
1	0	1
0	1	1
0	0	0
1	0	0
0	1	0
1	1	0
0	0	1
1	1	0
1	0	1
0	1	1
0	0	0

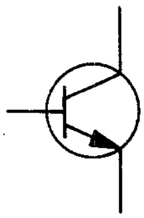
NOTE

Open circle indicates an inverter.

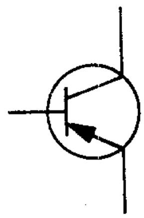
1.2.2.18 Electrical filter.-

1.2.2.19 Transistors.-

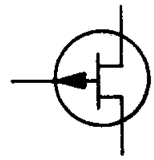
A. NPN



B. PNP



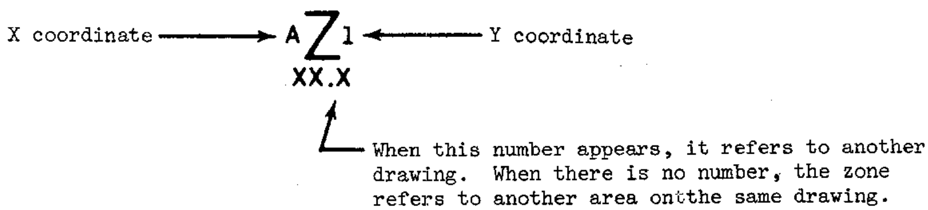
C. FET P-channel



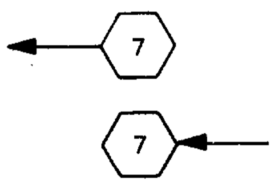
1.2.3 Miscellaneous Symbols

1.2.3.1 Drawing notes.- Notes are of two types: general and specific. General notes do not apply to a specific area on the drawing. Specific notes do apply to a specific area or areas of the drawing and are indicated with a note flag (shown below) which appears in the area or areas referenced.

1.2.3.2 Technical zone reference.- Zone references direct attention from one area to another in the same or another drawing. The "Z" shown below, with appropriate zone locators, indicates the exact area referenced.



The hexagon ("hex"), shown below, is used to connect one line to another line on the same or on another drawing. The appropriate "Z" appears next to the "hex" to direct attention to the location of the corresponding reference.



2 GENERAL INFORMATION

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SECTION 2
GENERAL INFORMATION

2.1 LRV DESCRIPTION

The LRV is a four-wheeled, electrically propelled, manually controlled vehicle to be used for transporting crewmen and equipment on the lunar surface. The vehicle has accommodations for two crewmen and has the stowed auxiliary equipment designed for a particular mission.

Either crewman may control the LRV by utilizing the hand controller installed midway between the two seats. All controls and displays are located on one panel for easy use from either seat. These controls and displays include switches for drive motors, steering motors, main batteries, and redundant systems selection. Displays of battery parameters, navigation data, and temperatures of critical components are provided. Circuit breakers are located in groups on the same control panel.

The LRV consists of the following major subsystems and components: structure, mobility, crew station, electrical, navigation, and stowed payload.

3 STRUCTURE

SECTION 3

STRUCTURE

3.1 SUBSYSTEM DESCRIPTION

The LRV structure subsystem consists of the chassis (Drawing 3.1), passive and active thermal control devices, and dust control devices.

3.2 THERMAL CONTROL

Thermal control (Drawing 3.2) is provided in the forms of surface finish, thermal straps, fusible heat sinks, insulation blankets, and thermal mirrors.

Surface finishes are either anodized or painted with thermal control paints.

Thermal straps are either 2 layers (on DGU) or 140 layers (on SPU) of .001 aluminum foil welded to aluminum end pieces.

The fusible heat sinks consist of solid paraffin wax in an aluminum container.

The insulation (or thermal) blanket is assembled from 15 layers of perforated aluminized mylar with 14 layers of interspersed nylon netting.

The thermal mirrors use a silver film on glass--these are dust sensitive. If over 5 percent dust is present on the surface, these will not radiate to the efficiency necessary for adequate cooldown of equipment during rest periods. This affects the batteries which not only store up discharge heat but also act as a heat sink for other components.

3.3 DUST CONTROL

Dust control is incorporated into the LRV to minimize the effect of lunar dust on the equipment and crew. Dust control is provided by means of fenders, boots, covers, seals, and caps.

Fiber-glass fenders control the dust created by the wheels. The fenders consist of a fixed section and a sliding section which must be extended by the crew upon deployment on the lunar surface.

A boot around the base of the hand controller grip provides control against dust entering the mechanism.

The steering sectors in the forward and aft chassis are enclosed with structure, beta cloth, and boots for dust control.

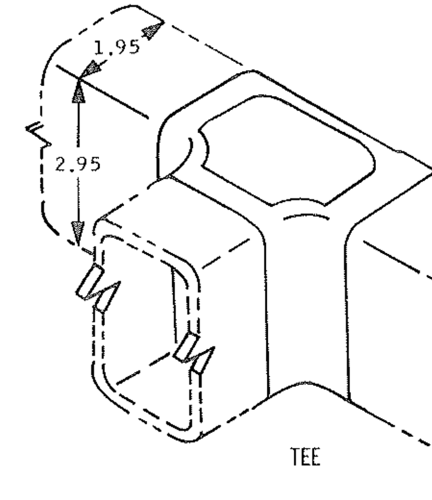
All working joints of the suspension system are protected from dust by seals and dust caps.

The traction drive assemblies are hermetically sealed thus preventing entry of lunar dust.

Dust control for the brakes is provided by circumferential shields around the drums and boots around the brake levers.

The piston rod of the linear damper is protected from dust by a cylindrical sleeve and by seals.

Fiber-glass covers over the batteries, DCE, and SPU provide dust protection for the thermal mirrors while closed.



LTR	PCN	DR	ENG	DATE	APPROVAL
COMMENTS:					

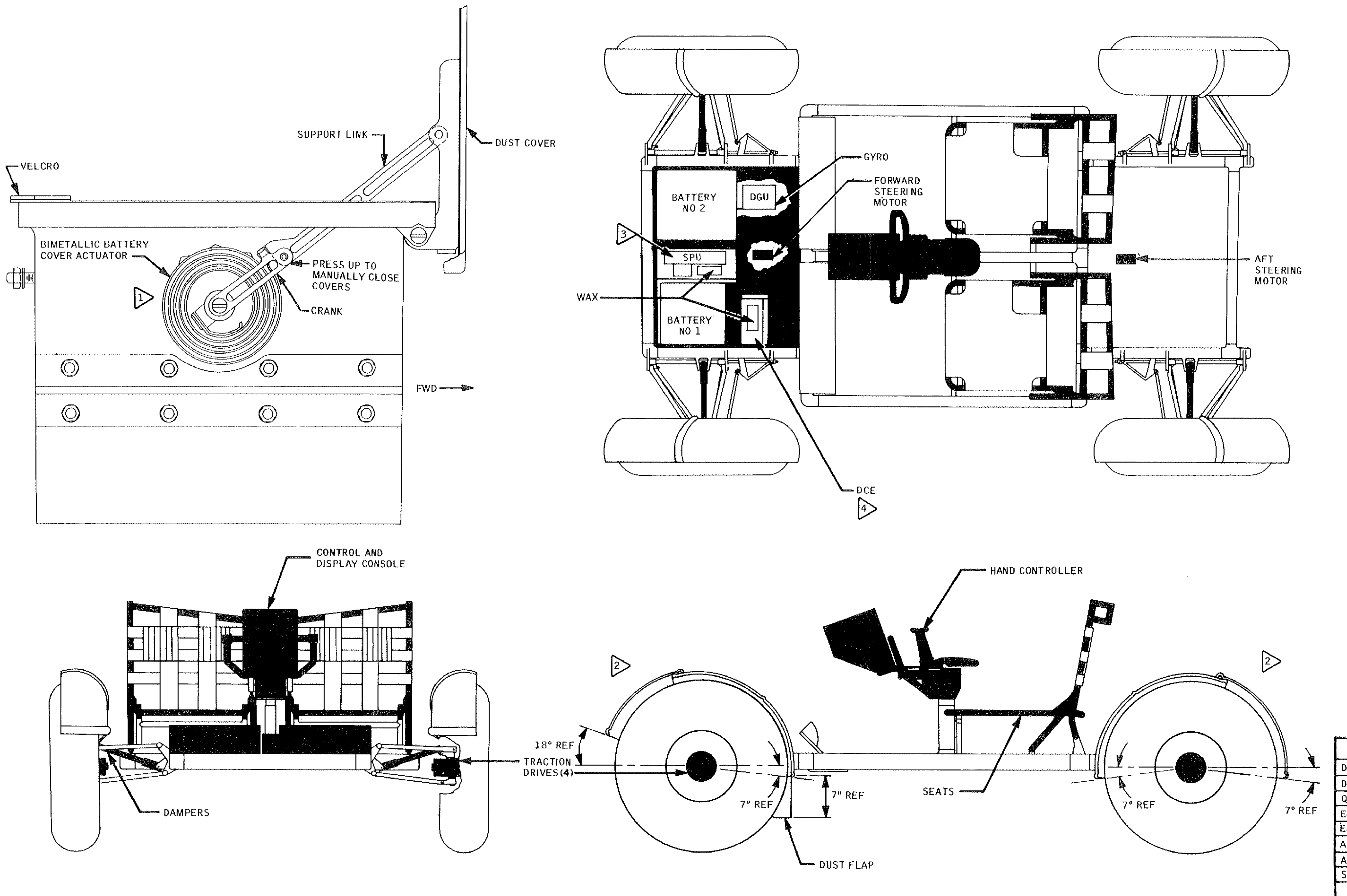
4 FENDER EXTENSIONS DEPLOYED BY CREW

3 OUTBOARD TOE HOLD IS THE CENTER MEMBER OF THE DEPLOYMENT TRIPOD AND MAY BE INSTALLED BY THE CREW AFTER THE LRV IS DEPLOYED. IT ALSO MAY BE STOWED UNDER THE FOOTREST FOR USE AS A WHEEL DECOUPLING TOOL

2 HINGES

NOTES: 1 HINGE IS LOCKED IN DEPLOYED POSITION WHEN LOCK PIN IS FLUSH WITH CHASSIS.

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR		
DSGN		
QC [signature]	1-6-72	CHASSIS
ENGR [signature]	1-6-72	
ENGR [signature]	10-2-72	
APP Gerald D. Griffith	10-2-72	
APP		LRV / DWG NO 3.1
STC [signature]	10/2/72	APOLLO 17
		55 X 17 / PAGE 3-3 / SHEET 1 OF 1



BLACK INDICATES AREAS HAVING THERMAL CONTROL BY SURFACE FINISH

NOTES:

1. AT 50° F OR BELOW BATTERY TEMPERATURE, THE COVER WILL CLOSE
2. FENDER SHOWN DEPLOYED
3. SURVIVAL LIMITS FOR SPU: -65° F TO +185° F
   OPERATING LIMITS FOR SPU: +30° F TO +130° F
   SPU USES 2-1/4 LB EICOSANE PARAFFIN WAX (MELTING POINT 98° F) FOR PARTIAL THERMAL CONTROL WITH THERMAL STRAP TO BATTERY NO 1
4. SURVIVAL LIMITS FOR DCE: -20° F TO +180° F
   OPERATING LIMITS FOR DCE: 0° F TO +159° F
   DCE USES 3-1/2 LB OCTADECANE PARAFFIN WAX (MELTING POINT 85° F) FOR PARTIAL THERMAL CONTROL

LTR	PGN	DR	ENG	DATE	APPROVAL

COMMENTS:

SIGNATURES	DATE
DR	
DSGN	
QC [illegible]	1-6-72
ENGR [illegible]	1-6-72
ENGR [illegible]	10/2/72
APP Gerald D. Griffith	10/2/72
APP	
STC [illegible]	10-2-72

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MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

THERMAL CONTROL

LRV
APOLLO 17

DWG NO 3.2

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4 MOBILITY

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SECTION 4

MOBILITY

4.1 SUBSYSTEM DESCRIPTION

The LRV mobility subsystem consists of the wheels, suspension, traction drive, steering mechanical, steering electrical, and drive control electronics.

4.2 WHEEL

Each wheel (Drawing 4.1) consists of an open wire mesh tire with chevron thread covering 50 percent of the surface contact area. The tire inner frame (bump stop) prevents excessive deflection of the outer wire mesh frame under high impact load conditions. In an emergency, the vehicle can operate with the bump stop only. Normally, each tire is capable of maintaining full operations with 10 percent of the wire elements broken. If the wire elements are broken, they are a potential hazard to the astronaut working in the area.

Each wheel can be upcoupled from the traction drive by operation of the two decoupling mechanisms (Drawing 4.2), which allow the wheel to "free-wheel" about a bearing surface independent of the drive train for up to 100 km of lunar operation. The decoupling mechanism can also be used to re-engage the wheel with the traction drive. Either outboard toehold can be used as the wheel decoupling tool. Decoupling a wheel results in a nonfunctional brake and odometer for that wheel.

4.3 SUSPENSION

The chassis is suspended from each wheel by a pair of parallel triangular arms connected between the LRV chassis and each traction drive. (See Drawing 4.3 for the suspension system.) Loads are transmitted to the chassis through each suspension arm to a separate torsion bar for each arm. The upper torsion bars are used primarily to deploy the wheels from the stowed condition. Deployed, they carry about 15 percent of each wheel load, with the lower torsion bars carrying the remaining 85 percent. Wheel vertical travel and rate of travel is limited by a damper connection between the chassis and each upper suspension arm. The damper limits wheel vertical travel to 6 inches of jounce and 4 inches of rebound under nominal load conditions. The combination deflection of the suspension system/tires allows 14 inches of chassis ground clearance when the LRV is fully loaded and 17 inches when unloaded.

Damping energy heat is transferred to the silicone oil (47 cc) in the damper. The heat is then conducted from the oil to the damper walls for dissipation.

The suspension assembly is rotatable approximately 135 degrees to allow LRV stowage in the LM.

4.4 TRACTION DRIVE

Each wheel is provided with a separate traction drive assembly (Drawing 4.4) consisting of a harmonic drive reduction unit, drive motor, and brake assembly. Each traction drive is hermetically sealed to maintain a 7.5 psia internal pressure for optimum thermal control. Decoupling a wheel also decouples that traction drive assembly.

4.4.1 Harmonic Drive

The four harmonic drive reduction units transmit torque to each wheel. Input torque to the four harmonic drives is supplied by the four electric drive motors. The harmonic drives reduce the motor speed at the rate of 80:1 and allow continuous application of torque to the wheels at all speeds without requiring gear shifting. Each traction drive also contains an odometer pickup which transmits pulses to the navigation system signal processing unit at the rate of 9 pulses per wheel revolution.

4.4.2 Drive Motor

The drive motors are direct-current series, brush-type motors which operate from a nominal input voltage of 36 Vdc. Speed control for the motors is furnished by pulse width modulation from the drive controller electronics package. Each motor housing also forms the kingpin for the LRV steering system. Each motor is instrumented for thermal monitoring. An analog temperature output from a thermistor located in the field winding is transmitted for display on the control and display panel. In addition, each motor contains a thermal switch which closes at excessive temperatures and provides an input signal to the caution and warning system to actuate the warning flag.

4.4.3 Brakes

Each traction drive is equipped with a mechanical brake (Drawing 4.5) actuated by a cable connected to a linkage in the hand controller (Drawing 5.4). Braking is accomplished by moving the hand controller rearward. Brakes are effectively locked at 12° of hand controller aft movement. Drive power inhibit is actuated by a switch at 15° of hand controller aft movement. Decoupling a wheel also decouples the brake for that wheel.

4.5 STEERING

4.5.1 Steering Mechanical

LRV steering (Drawing 4.6) is accomplished by Ackerman-geometry steering of both the front and rear wheels allowing a wall-to-wall turning radius of 122 inches. Steering is controlled by moving the hand controller left or right from the nominal position. This operation energizes separate electric motors for the front and rear wheels and provides through a servosystem a steering angle proportional to the position of the hand controller.

Each steering motor is connected to a speed reducer which drives a spur gear sector which, in turn, actuates the steering linkage to accomplish the change in steering angle. Maximum travel position of the sector provides an outer wheel angle of 22° and inner wheel angle of 50°. The steering rate is such that lock-to-lock steering can be accomplished in 5.5 ± 0.5 seconds.

The front and rear steering assemblies are mechanically independent of each other. In the event single Ackerman steering is desired or for a motor/speed reducer failure, the steering linkage can be disengaged from a sector, the wheels can be manually centered

*

and locked, and operations can continue using the remaining active steering assembly. Forward steering re-engagement cannot be accomplished by a crewman. The aft steering can be re-engaged using the special tool stowed on the aft chassis. This tool is used to retract the locking pin from the steering sector.

4.5.2 Steering Electrical

The steering electrical system (Drawing 4.7) is a servosystem. A signal generated by deflection of the hand controller is coupled to the input servoamplifier as an error signal across a bridge. This error signal is amplified and applied to the steering motor field coils in a direction determined by polarity of the input error signal (determined by the direction that the hand controller is deflected). The feedback pot is driven by the steering motor to a position that exactly cancels the original input error signal by balancing the bridge. Angular displacement of the wheels will then remain constant until the hand controller is moved to a new position.

The two steering motors are supplied power through separate circuit breakers from selectable electrical buses to provide redundancy.

Single Ackerman steering can be selected by centering the wheels and turning off either aft or forward steering power. This procedure may require occasionally recentering the disabled steering by turning on its drive power momentarily with the hand controller in the straight ahead position.

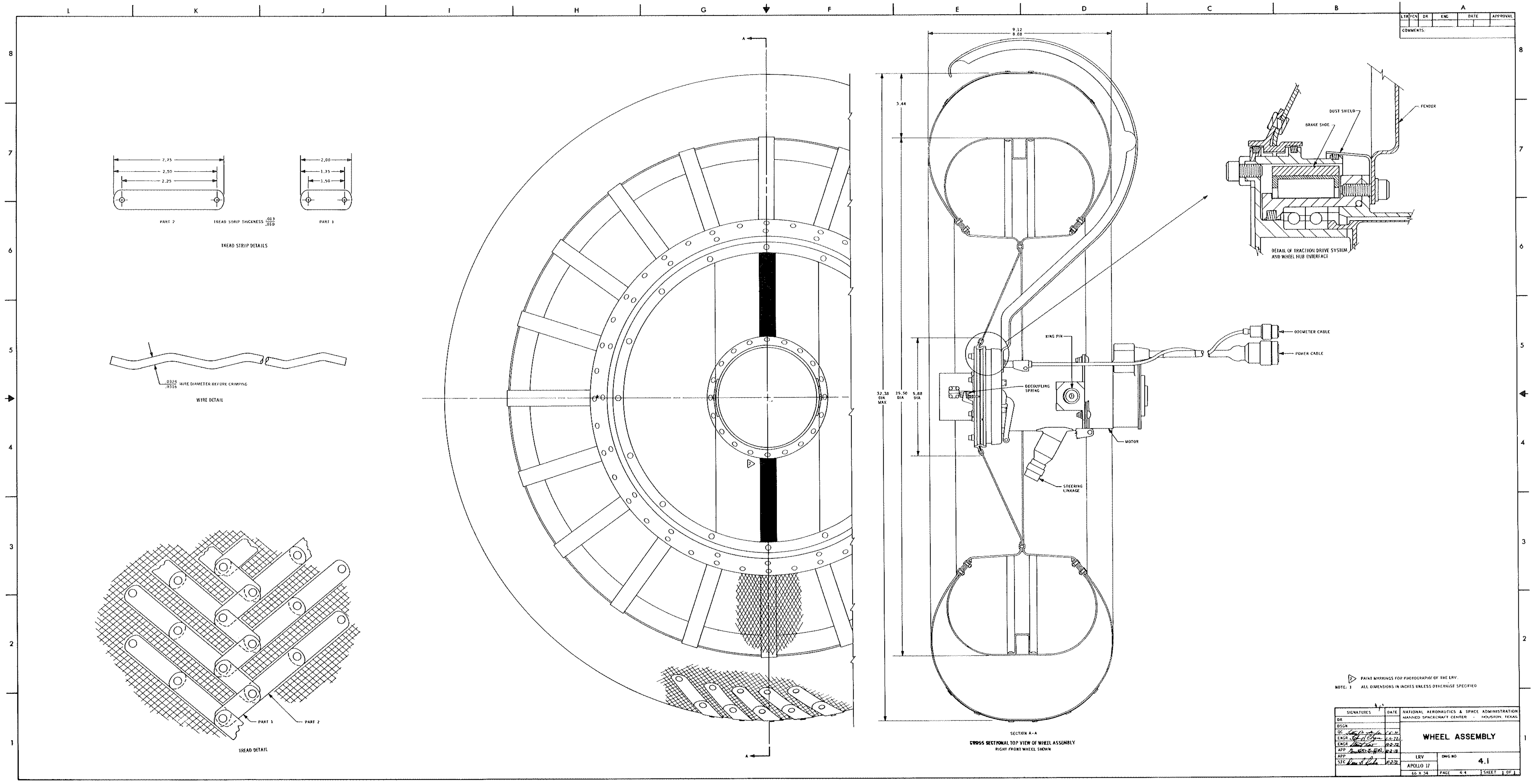
4.6 DRIVE CONTROL ELECTRONICS (Drawing 4.8)

A forward or rearward motion of the hand controller about the palm pivot point closes switches which select forward or reverse drive direction. This same movement causes a signal to be generated by the wiper of the traction drive pot. This signal controls the duty cycle modulation of the pulse width modulator (PWM). The pulse width of the PWM is proportional to the amount of hand controller deflection (throttle). This signal is then coupled through an inhibit gate to current-limited power transistors which in turn modulate 36 Vdc power to the drive motor field coils. The direction of current flow through the drive motor is determined by motor control relays which are normally controlled by the hand controller select switches.

Signals generated by the odometer reed switches in the traction drive prevent application of reverse drive motor power while moving forward or vice-versa if the LRV speed is greater than 1 km per hour. The vehicle should be completely stopped before attempting to change direction as the odometer inhibits are unpredictable between 1 km per hour and stopped.

Drive power is also inhibited by a drive power inhibit switch which closes at the hand controller aft 15° position (brakes nominally lock at 12° aft) or by getting a current overload signal from the current limiting circuits. Also, drive power is temporarily inhibited while changing directions to prevent switching the motor control relays under load.

Application of motor drive power when applying brakes is possible since the brakes lock at approximately 12° aft hand controller movement, and the brake inhibit logic is set at 15° aft hand controller movement. This is true for both forward and reverse drive power.



2,75
2,50
2,25
PART 2
TREAD STRIP THICKNESS .013 / .010
2,00
1,75
1,50
PART 1
TREAD STRIP DETAILS
.0324 / .0316 WIRE DIAMETER BEFORE CRIMPING
WIRE DETAIL
PART 1
PART 2
TREAD DETAIL
A
9.12 / 8.88
3.44
32.38 DIA MAX
25.50 DIA
5.88 DIA
KING PIN
DECOUPLING SPRING
MOTOR
STEERING LINKAGE
ODOMETER CABLE
POWER CABLE
DUST SHIELD
BRAKE SHOE
FENDER
DETAIL OF TRACTION DRIVE SYSTEM AND WHEEL HUB INTERFACE
SECTION A-A
CROSS SECTIONAL TOP VIEW OF WHEEL ASSEMBLY
RIGHT FRONT WHEEL SHOWN
LTR PCN DR ENG DATE APPROVAL
COMMENTS:
2 PAINT MARKINGS FOR PHOTOGRAPHY OF THE LRV.
NOTE: 1 ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED
SIGNATURES
DATE
DR
DSGN
QC
ENGR
ENGR
APP
APP
SJC
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
WHEEL ASSEMBLY
LRV
APOLLO 17
DWG NO 4.1
66 X 34
PAGE 4-4
SHEET 1 OF 1

LTR	PCN	DR	ENG	DATE	APPROVAL

COMMENTS:

6. RECOUPLING IS ACCOMPLISHED BY ALIGNING THE CLEVISES AND RETURNING THE PINS
5. DECOUPLING RIGHT REAR WHEEL DISABLES SPEEDOMETER
4. DECOUPLING ANY TWO WHEELS DISABLES THE NAV SUBSYSTEM RANGE, BEARING AND DISTANCE DISPLAYS (SPU LOGIC SELECTS THIRD FASTEST WHEEL FOR DISTANCE COMPUTATIONS)
3. DECOUPLING DISABLES BRAKES, DRIVE, AND ODOMETER TO THAT WHEEL
2. TO DECOUPLE WHEEL, PULL SPRING OUT AND ROTATE ABOUT WHEEL CENTERLINE
1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

SIGNATURES	DATE
DR Linda S. Draculi	11-29-71
DSGN	
QC Betty M. Taylor	1-6-72
ENGR John H Cooper	10-2-72
Stuart Ross	10-2-72
APP Gerald D Griffith	10-2-72
STC Dean B Fisher	10-2-72

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MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

DECOUPLING ASSEMBLY

LRV
APOLLO 17

NO. 4.2

34 X 10.5 | PAGE 4-5 | SHEET 1 OF 1

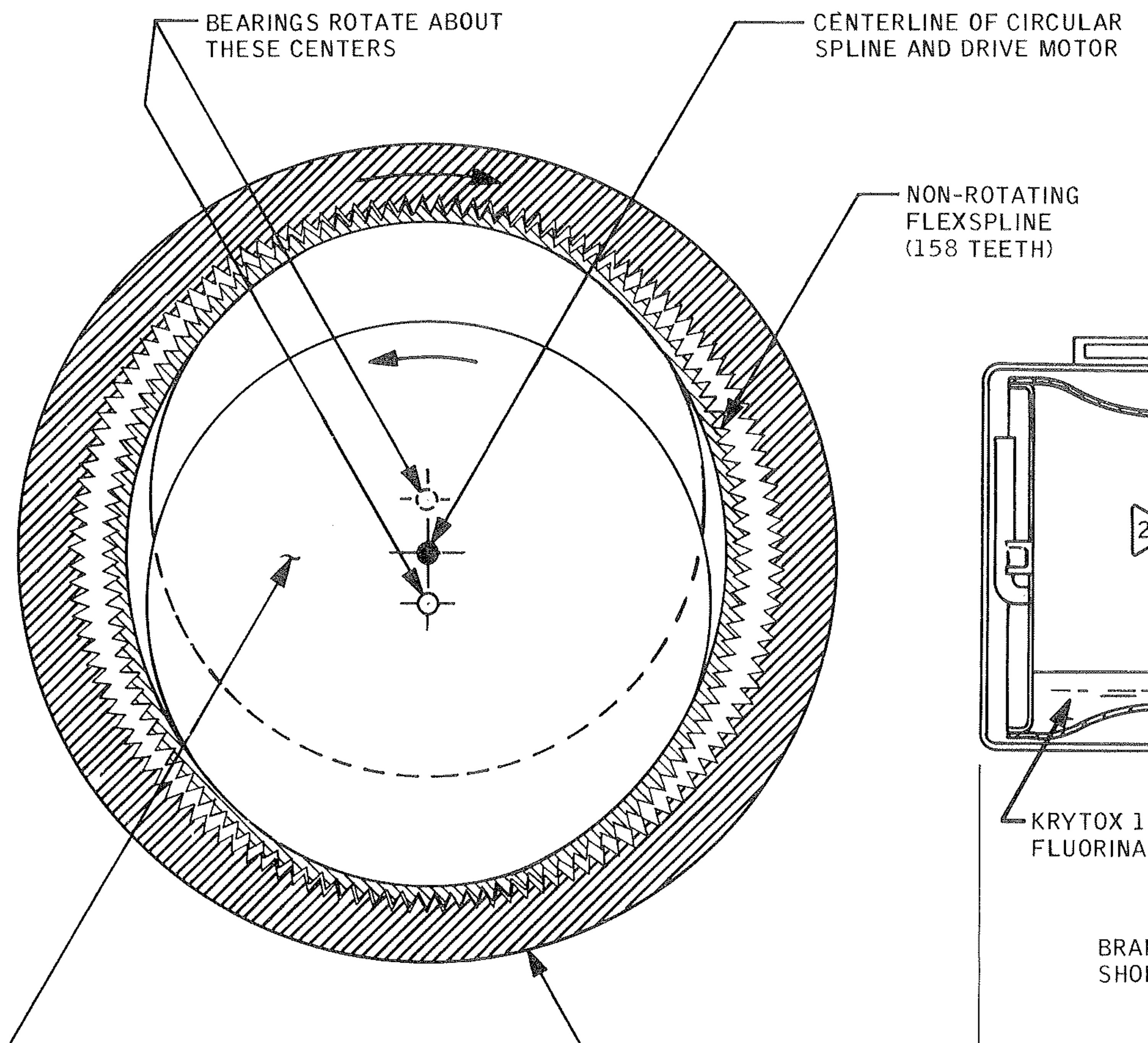
LTR	PCN	DR	ENG	DATE	APPROVAL

COMMENTS:

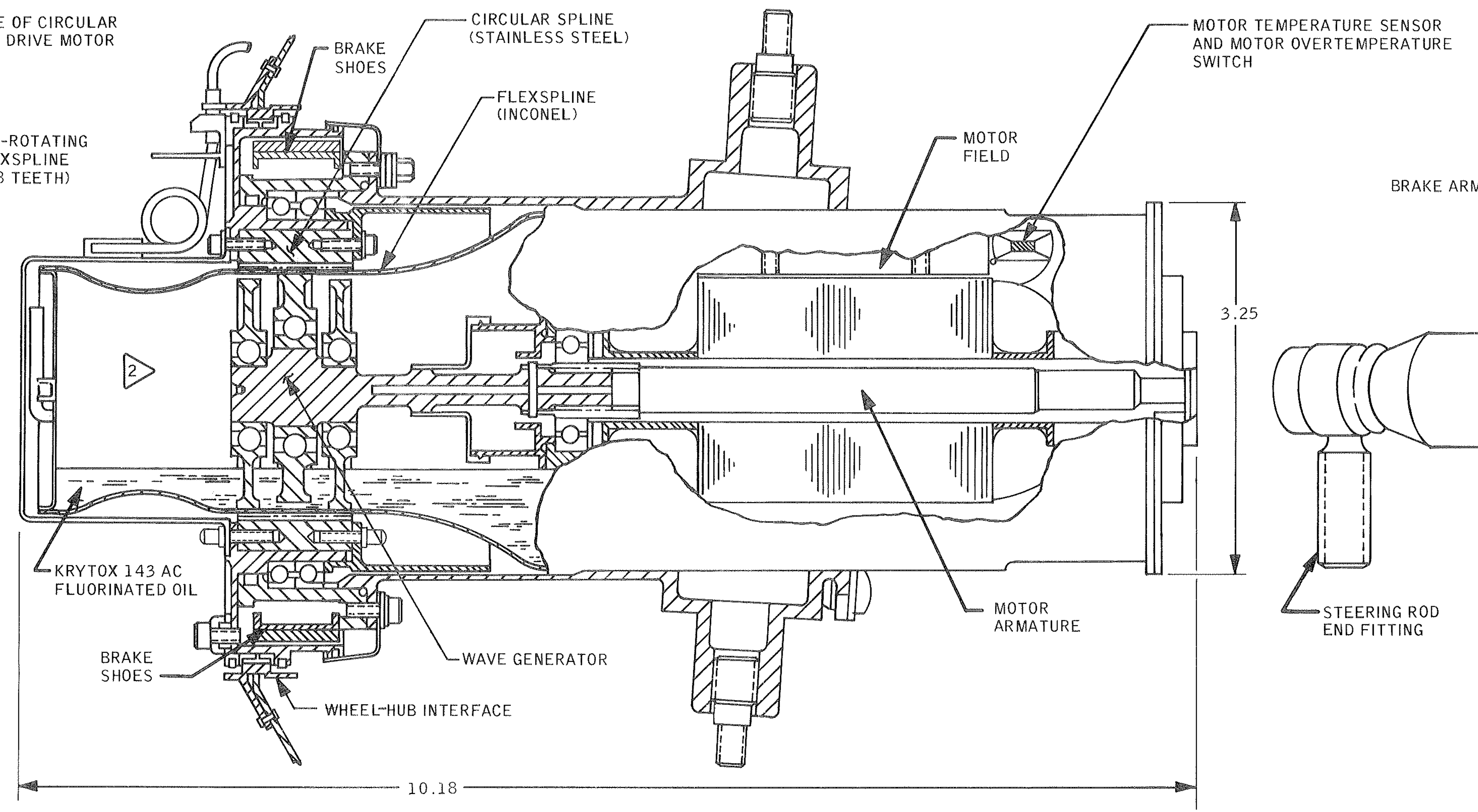
NOTES:

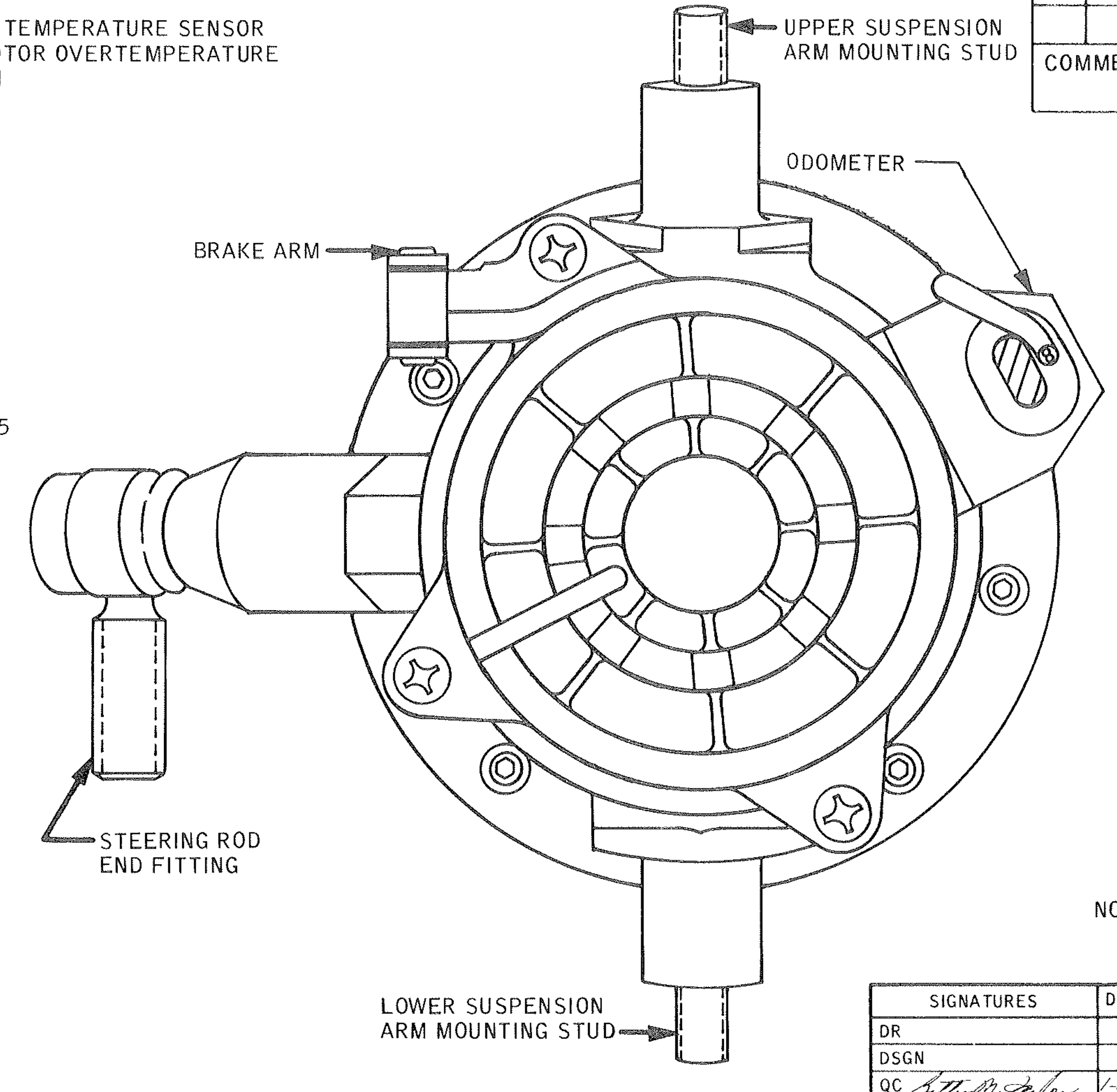
1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
2. LINEAR DAMPER SURVIVAL TEMPERATURES ARE -65° F TO +400° F. ALL OTHER COMPONENTS OF SUSPENSION SYSTEM HAVE A TEMPERATURE RANGE OF -100° F TO +300° F
3. CHASSIS HAS 17 INCHES GROUND CLEARANCE UNLOADED AND 14 INCHES WITH VEHICLE FULLY LOADED

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR		
DSGN		
QC [signature]	1-6-72	**SUSPENSION SYSTEM**
ENGR [signature]	1-6-72	
ENGR [signature]	10-2-72	
APP Gerald D. Griffith	10-2-72	
APP		LRV
STC [signature]	10-2-72	APOLLO 17 / 4.3
		55 X 17 / PAGE 4-6 / SHEET 1 OF 1



END VIEW OF HARMONIC DRIVE ASSY
FUNCTIONAL DIAGRAM
(NOT TO SCALE)





TRACTION DRIVE ASSEMBLY
REAR VIEW

LTR	PCN	DR	ENGR	DATE	APPROVAL

COMMENTS:

2 INTERIOR OF HARMONIC DRIVE IS PRESSURIZED WITH NITROGEN GAS AT 7.5 PSI

NOTE: 1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR		
DSGN		TRACTION DRIVE ASSEMBLY
QC	1-6-72	
ENGR	10-2-72	
	10-2-72	
APP	10-2-72	
STC	10-2-72	LRV APOLLO 17 — NO. 4.4
34 X 10.5	PAGE 4-7	SHEET 1 OF 1

NOTE: 1. BRAKE BAND LINING THICKNESS 0.115 INCHES WIDTH 0.735 INCHES

H Z 1
5.4

LTR	PCN	DR	ENG	DATE	APPROVAL

COMMENTS:

SIGNATURES	DATE
DR	
DSGN	
QC Betty M. Taylor	1-6-72
ENGR John H. Cooper	10-2-72
Stuart Laws	10-2-72
APP Gerald D. Griffith	10-2-72
STC Dean B. Parker	10-2-72

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BRAKE ASSEMBLY

LRV
APOLLO 17

NO. 4.5

34 X 10.5 | PAGE 4-8 | SHEET 1 OF 1


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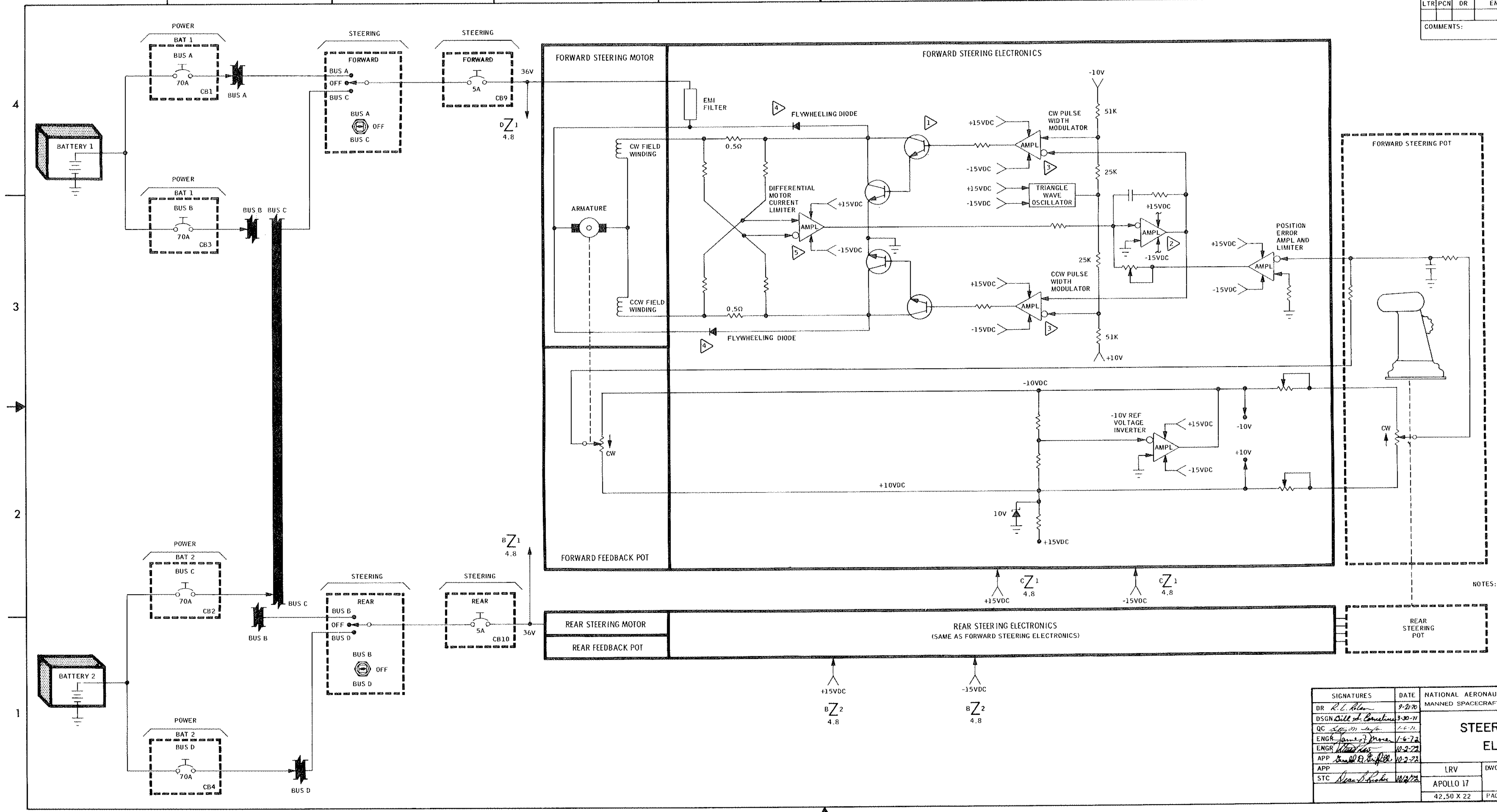
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
STEERING SYSTEM
MECHANICAL
LRV
APOLLO 17
DWG NO
4.6
SIGNATURES
DATE
DR
DSGN
ENGR
APP
STC



NOTES:

1. A PLUS VOLTAGE TURNS TRANSISTOR ON
2. INTEGRATES ERROR SIGNAL LESS OUTPUT OF CURRENT LIMITER AND APPLIES MIXED OUTPUT TO THE PULSE WIDTH MODULATORS
3. AMPLITUDE MODULATED ERROR SIGNAL AND TRIANGLE WAVE OSCILLATOR RESULT IN PULSE WIDTH MODULATION DRIVING SIGNAL TO MOTOR TRANSISTORS
4. FLYWHEEL DIODES ALLOW MOTOR FIELDS TO COLLAPSE AFTER EACH PULSE PROVIDING ADDITIONAL POWER
5. CURRENT LIMITING IS HELD TO 1.8 AMPS IN EITHER FIELD WITH RESPECT TO THE OTHER

SIGNATURES	DATE
DR R. L. Rolan	9-21-70
DSGN Bill A. Cornelius	3-30-71
QC	1-6-72
ENGR James J. Moran	1-6-72
ENGR	10-2-72
APP	10-2-72
APP	
STC	10/2/72

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
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STEERING SYSTEM ELECTRICAL

LRV
APOLLO 17
42.50 X 22
DWG NO 4.7
PAGE 4-10
SHEET 1 OF 1

TO STEERING CONTROL REAR
FROM STEERING MOTOR REAR SWITCH
SIGNATURES
DATE
DR
DSGN
QC
ENGR
ENGR
APP
APP
SIC
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
DRIVE CONTROL ELECTRONICS
LRV
APOLLO 17
DWG NO
4.8
104.5 X 34
PAGE 4-11
SHEET 1 OF 1

5 CREW STATION

*

SECTION 5

CREW STATION

5.1 HARDWARE

The crew station hardware consists of seats, footrests, inboard handholds, outboard handholds, armrest, floor panels, seat belts, fenders, and toeholds (Drawing 5.1).

5.1.1 Seats

The two LRV seats are tubular aluminum frames spanned by nylon. The seats are folded flat onto the center chassis for launch and are erected by the crew after LRV deployment on the lunar surface. The seat back is used to support and restrain the portable life support system (PLSS) from lateral motion when the crew members are seated. The seat erection sequence is shown on Drawing 5.1. The seat bottom contains a cutout to allow the crew access to the PLSS flow control valves and includes vertical supports for the PLSS. A stowage bag is provided under each sheet.

5.1.2 Footrests

For launch, the footrests are stowed against the center chassis floor where they are held by a Velcro pad. The basic footrest is deployed by the crew on the lunar surface and is adjustable prelaunch to accommodate various size crewmen.

5.1.3 Inboard and Outboard Handholds

The inboard handholds are constructed of 1-inch o.d. aluminum tubing and are used to aid the crew in ingress of the LRV. These handholds also contain identical payload attach receptacles for the 16-mm data-acquisition camera and the lunar communications relay unit (LCRU) low-gain antenna.

The outboard handholds are integral parts of the chassis. These handholds are used to provide crew comfort and stability when seated on the LRV. They are also used for seatbelt attachment.

5.1.4 Armrest

The armrest is used to support the inboard arm of both crewmen when seated to prevent arm fatigue and to support the arm of the operator during hand controller operation.

5.1.5 Floor Panels

The floor panels in the crew station area are beaded aluminum panels. The floor is structurally capable of supporting the static full weight of standing astronauts while on the lunar surface.

5.1.6 Seatbelts

Nylon webbing seatbelts are provided for each seat. The belt end terminates in a hook which is used to attach and remove the belt to the outboard handhold. Length of the belt is adjusted by a buckle with an over-center latch. The latch is designed to take up 3 inches of slack.

5.1.7 Fenders

The retractable portion of each fender is deployed by the astronaut during LRV activation on the lunar surface.

5.1.8 Outboard Toehold

The outboard toeholds are used to aid the crew in egressing the LRV in one-sixth gravity operations. Each toehold is formed by dismantling the left and right LRV/LM interface tripods. The leg previously pinned to the center chassis longitudinal member is used as the toehold. The tripod member is inserted into the chassis receptacle where it is secured with a ball pin to form the operational position of the toehold. It is also the tool used to decouple the wheel, to release the telescoping tubes and saddle fitting on the forward chassis, and to free the steering decoupling rings from the stowed position. Either toehold may be used as a tool.

5.2 CONTROL AND DISPLAY PANEL

The control and display panel (Drawing 5.2) is separated into two functional parts: navigation on the upper part of the panel and monitoring/controls on the lower part. The function of each device on the panel is explained below.

5.2.1 Navigation Displays

A. Attitude indicator - This instrument provides indications of LRV pitch and roll. It indicates PITCH upslope (U) or downslope (D) within a range of plus 25 to minus 25 degrees in five-degree increments. The damper on the side of the indicator can be moved to the right in order to damp out oscillations. To read roll angles, the indicator is rotated forward which exposes the ROLL scale to the left-side crewman. The ROLL scale is graduated in one-degree increments 25 degrees either side of zero.

B. Integrated position indicator (IPI) - The IPI consists of the heading compass card, range- and bearing-to-LM digital indicators, and a total-distance-traveled indicator. The indicators are described individually.

C. HEADING (M6) - This compass rose indicator displays the LRV heading with respect to lunar north. The initial setting and updating of the heading indicator is accomplished by operating the GYRO TORQUING switch LEFT or RIGHT. The indicator is calibrated in two-degree increments.

D. BEARING (M6) - This digital indicator displays bearing to the LM. This indicator reads in one-degree digits. In the event of power loss or undervoltage to the navigation system, the BEARING indication will remain intact. Restoration of normal power may cause loss on the indications.

E. DISTANCE (M6) - This digital indicator displays distance traveled by the LRV in increments of 0.1 km. This display is driven from the navigation signal processing unit which, in turn, receives its inputs from the third-fastest traction-drive odometer. Total digital scale capacity is 99.9 km. Power loss will freeze the reading but restoration of normal power may cause the indicator to assume random values.

F. RANGE (M6) - This digital indicator displays the distance to the LM and, like the BEARING display, will remain intact in the event of power failure with possible loss of information after restoration of power. Total digital scale capacity is 99.9 km, graduated on 0.1-km increments.

NOTE

Operation in reverse adds to the distance-traveled display and will bias the range and bearing values.

G. Sun shadow device - This device is used to determine the LRV heading with respect to the sun. The scale length is 15 degrees either side of zero with one-degree divisions. The sun shadow device can be utilized at sun angles up to 75° (zenith).

H. SPEED (M5) - This indicator shows LRV velocity from 0 to 20 km/hr. This display is driven from the odometer pulses from the right rear wheel, through the SPU.

NOTE

There is no speed indication when the NAV POWER circuit breaker is open or the right rear wheel is decoupled.

5.2.2 Navigation Switches and Circuit Breaker

A. GYRO TORQUING (S15) - This switch is used to slew the navigation gyro at the rate of 1.5°/sec to adjust the HEADING indication during navigation updates. Placing the switch in LEFT moves the HEADING scale clockwise. With the switch in RIGHT, the scale rotates counterclockwise. There is a 2-minute torquing limit with a 5-minute cooldown period afterwards. This allows 180° of gyro torquing per cycle.

B. NAV POWER (CB13) - This circuit breaker is used to route power from the main buses B and D to the navigation subsystem. The navigation and power distribution system is designed to provide power for the navigation system from either battery simultaneously to preclude power loss in the event of failure of one battery. With this circuit breaker in the open position, the SPU will not function, causing loss of speed indication and allowing no changes in the navigation displays. Restoring navigation power may cause the navigation displays to assume random readings.

C. SYSTEM RESET (S14) - This switch is used to reset the BEARING, DISTANCE, and RANGE digital displays to zero. This switch requires pulling the toggle out, then placing it in the operating position. This feature is designed to prevent inadvertant actuation of the switch.

5.2.3 Power Section Circuit Breakers and Switch

A. AUX (CB14) - This circuit breaker is used to route power to the auxiliary connector at the forward end of the LRV. This circuit breaker receives input power from both batteries via buses A and C complete.

B. AUX POWER CB BYPASS (S-17) - Shorts around the aux circuit breaker when on. It is used only for post lift-off television.

C. BAT 1 BUS A (CB1) - This circuit breaker is used to energize bus A with power from battery 1.

D. BAT 1 BUS B (CB3) - This circuit breaker is used to energize bus B with power from battery 1.

E. BAT 2 BUS C (CB2) - This circuit breaker is used to energize bus C with power from battery 2.

F. BAT 2 BUS D (CB4) - This circuit breaker is used to energize bus D with power from battery 2.

G. ±15 DC PRIM/OFF/SEC switch (S11) - This switch is used to route 36 Vdc power from buses B and D to the ±15 DC PRIM (CB11) or ±15 DC SEC (CB12) circuit breakers.

H. ±15 DC PRIM (CB11) - This circuit breaker is used to route 36 Vdc power from the ±15 DC PRIM/OFF/SEC switch to the input of the primary ±15 volt dc power supply.

I. ±15 DC SEC (CB12) - This circuit breaker is used to route 36 Vdc power from the ±15 DC PRIM/OFF/SEC switch to the input of the secondary ±15 volt dc power supply.

5.2.4 Power/Temperature Monitor Switches and Meters

A. AMP-HR meter (M1) - This double-scale indicator is used to monitor remaining battery capacity in battery 1 and battery 2. At full charge, both the "1" and "2" reading should be 121 amp-hrs. These readings are not redundant.

B. VOLTS AMPS meter (M2) - This double-scale indicator is used to monitor the voltage or current being supplied from battery 1 and battery 2. Selection of which parameter (volts or amps) to monitor is controlled by the BATTERY SELECT switch. In order to use the same scale for accurate current and voltage, the scale is graduated from zero to 100. When the VOLTS X 1/2 position of the BATTERY SELECT switch is selected, the meter indication will be twice the value of the actual battery voltage (i.e., the indicator will read 72 for a voltage of 36 Vdc at the battery). Similarly, the current scale reads 2X the actual current flow. The allowable excursion of battery voltages, 66 to 82 (2X volts), is bracketed on the scale.

C. MOTOR TEMP SELECT (S13) - This switch is used to select the FORWARD or REAR drive motor temperature sensors to be monitored on the MOTOR °F indicator.

D. BATTERY SELECT (S12) - This switch is used to select either voltage or current of each battery on the VOLTS-AMPS indicator. This switch should be normally in the amps position so as to prevent unnecessary battery discharge.

E. BATTERY °F meter (M3) - This double-scale indicator is used to monitor the internal temperature of each battery. The allowable battery temperatures are bracketed on the meter.

F. MOTOR °F meter (M4) - This double-scale indicator is used to monitor the temperature of each drive motor. Either the front or rear wheels are monitored at any particular time. Both left and right wheels of either the front or rear set are monitored concurrently. Selection of which set of wheels to monitor is made by placing the MOTOR TEMP SELECT switch to either FORWARD or REAR position. The allowable motor temperatures are bracketed on the meter.

G. PWM SELECT (S16) - This switch is used to energize pulse width modulators in the motor controller. With the switch in the BOTH position, PWM 1 and PWM 2 are both energized, and selection of either PWM 1 or PWM 2 can be made for control of any of the four drive motors. Placing the switch in the "1" position inhibits power from energizing PWM 2 and all the DRIVE ENABLE switches must be placed in the PWM 1 position to achieve motor control. Similarly, if the "2" position is selected, power to PWM 1 will be inhibited and all DRIVE ENABLE switches must be placed in the PWM 2 position to control the drive motors. If this switch is placed in PWM 1 or PWM 2 position with the corresponding DRIVE ENABLE switches in an opposite position, those traction drives which are so set will have full on drive power applied to them. This condition may be intentionally introduced as a contingency means of controlling the vehicle. It is known as the "jackrabbit" mode.

5.2.5 Steering Switches and Circuit Breakers

A. FORWARD steering switch (S9) - This switch is used to select either bus A or bus C to supply power to the forward steering motor. Power is routed from bus A or bus C through this switch to the input side of the FORWARD steering motor circuit breaker (CB9).

B. FORWARD steering circuit breaker (CB9) - This circuit breaker is used to protect the forward steering motor. Electrical power is routed from bus A or bus C through the FORWARD steering switch (S9) to the input side of the FORWARD steering circuit breaker. With the circuit breaker closed, power is then routed directly to the steering motor armature and to the DCE power supply where it energizes a relay routing ±15 dc power to the forward steering electronics.

C. REAR steering switch (S10) - This switch is used to select either bus B or bus D to supply power to the rear steering motor. Power is routed from bus B or bus D through this switch to the input side of the REAR steering motor circuit breaker (CB10).

D. REAR steering circuit breaker (CB10) - This circuit breaker is used for the rear steering motor in the same manner as described for the FORWARD steering circuit breaker.

5.2.6 Drive Power Switches and Circuit Breakers

A. LF (CB5), LR (CB7), RF (CB6), and RR (CB8) circuit breakers - These circuit breakers are used to protect the four drive motors from overload damage. The right rear (RR) and left rear (LR) circuit breakers receive power from bus B or bus D, depending on the drive power switches. The right front (RF) and left front (LF) circuit breakers receive power from bus A or C, depending on the setting of the drive power switches.

B. LF (S5), LR (S7), RF (S6), and RR (S8) switches - These switches are used to select the appropriate bus to supply power to a specific drive motor. The left front (LF) and right front (RF) drive motors are powered from bus A when the LF and RF switches are in the BUS A position. With the switches in the BUS C position, the left front and right front motors are supplied power from bus C. In the OFF position, the switch prevents power from reaching the drive power circuit breakers. The rear drive motors are similarly powered by selecting the BUS B, BUS D, or OFF positions of the switches. These switches also energize a relay in the DCE which applies ± 15 Vdc power to the selected electronics.

5.2.7 Drive Enable Switches

LF (S1), LR (S3), RF (S2), and RR (S4) switches - These switches are used to select either pulse width modulator 1 or 2 for control of a specific drive motor. With any switch in the PWM 1 position, pulse width modulator 1 will be used to control the drive motor of the appropriate switch (i.e., left rear, right rear, left front, or right front). In the OFF position, full drive power is continuously applied to the applicable drive motor. Thus, the "OFF" position should only be used during contingency modes of operation. These switches have guards placed around them. This is a second method of configuring the contingency "jackrabbit" mode (see Paragraph 5.2.4.G).

5.2.8 Caution and Warning System

The caution and warning system is shown schematically as an entity in Drawing 5.3. The normally open temperature switches in the batteries and drive motors close on increasing temperatures. When either battery reaches $125 \pm 5°$ F or any drive motor reaches $400 \pm 12°$ F, the temperature switch closes, energizing the OR logic element and the driver. The driver then sends a 10-millisecond, 36-V pulse to the coil of the electromagnet which releases the magnetic hold on the indicator at the top of the console and a spring-loaded flag flips up. The astronaut resets the flag by pushing it down. The flag will not be released again by the same element until that element first resets.

5.3 HAND CONTROLLER

The hand controller (Drawing 5.4) provides the steering, speed, and braking commands. Forward movement of the hand controller about the palm pivot point proportionally increases forward speed. Right and left movements provide inputs to the two steering motors allowing directional control. Moving the reverse inhibit switch down and moving the hand controller 14° rearward past the neutral palm pivot point provides reverse power. Bringing the controller rearward about its lower pivot point initiates braking. The parking brake is engaged by moving the controller fully rearward. To release the parking brake, move the hand controller to a steer hard left position. (In the event of malfunction of the brake release, the contingency parking brake release ring, shown in Drawing 5.4, can be pulled to release the brake.)

It is possible for either forward or reverse power to be applied while braking since the hand controller must be moved through about 50 percent of its brake travel before the drive power inhibit logic is energized.

TABLE 5-I.- CIRCUIT BREAKER TRIP LEVELS

CB	Nom amp	Maximum trip current (trip 1 hr)				Minimum trip current (no trip 1 hr)				Time in sec (min-max) no preload current @77°F % of nominal current	
		0°F	+77°F	+180°F	+180°F @10^{-4}mm Hg	0°F	+77°F	+180°F	+180°F @10^{-4}mm Hg	200%	400%
CB1 CB2 CB3 CB4	70	105.0	101.5	80.0	77.0	84.0	73.5	59.0	45.9	15-70 sec	2-10 sec
CB5 CB6 CB7 CB8	25	40.0	37.5	31.5	27.0	36.3	28.75	17.5	15.0	15-40 sec	3-7 sec
CB9 CB10 CB11 CB12 CB13	5	8.75	7.5	5.0	4.7	7.4	5.75	3.0	2.5	15-40 sec	1.5-4 sec
CB14	10.0	16.5	15.0	10.0	9.5	14.8	11.5	6.0	5.0	15-40 sec	1.5-4 sec

TABLE 5-II.- METER DATA - NAVIGATION DISPLAYS

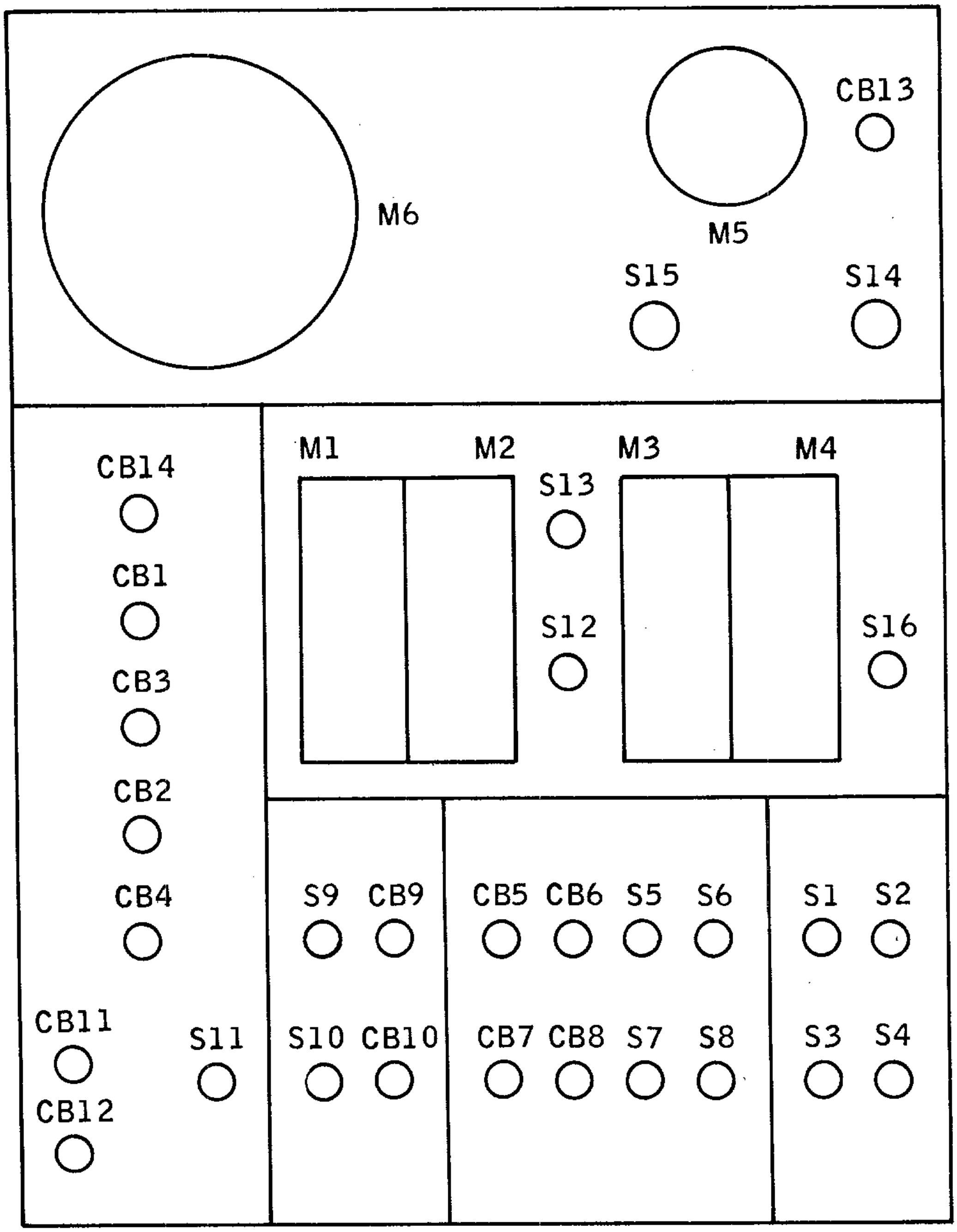
Data displayed	System 3σ accuracy	Display range	Display resolution
Heading[a]	±6°	0 to 360°	1 degree
Bearing to LM[a]	±6°	0 to 360°	1 degree
Range to LM	600 m at 5 km	0 to 30 km	0.1 km
Total distance traveled	2%	0 to 99 km	0.1 km
Velocity	1.5 km/hr	0 to 20 km/hr	1 km/hr
Sun angle	±2°	±15°	1°
Attitude			
Pitch	±3°	±25°	5°
Roll	±2°	±25°	1°
Fixed compensation 0.245 meters/pulse		Longitude - All	
Attitude to ±45°		Steering rates 50°/sec maximum	
Latitude to ±45°			

[a]Ref to lunar north

TABLE 5-III.- METER DATA - ENGINEERING PARAMETERS

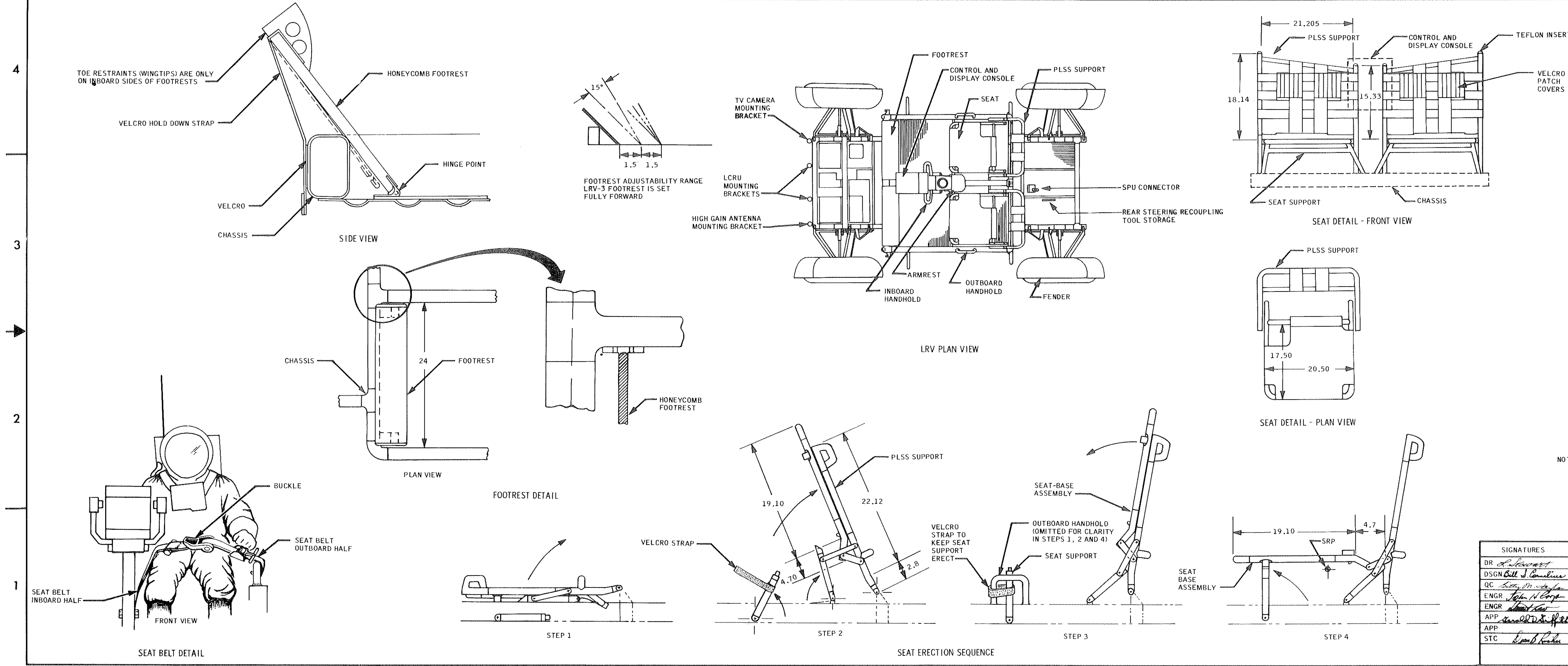
Meter	Units of measurement	Display range	Display resolution	Meter accuracy[b]
Amp-hour meter	Amp-hours	-15 to +120 A-h	10 A-h	2.8% full scale
Volts-amps meter	Volts:	0 to 100 V (divided by 2)	10 V (divided by 2)	2.8% full scale
	Amps:	0 to 100 A	10 A	2.8% full scale
Battery temp meter	Degrees Fahrenheit	0 to 180° F	20° F	2.8% full scale
Drive motor temp meter	Degrees Fahrenheit	200 to 500° F	50° F	2.8% full scale

[b]Meter accuracy is for meter only, not electronics.



NOTE: S17 aux power CB bypass switch is installed on left underside of the control and display console

Figure 5-1. - Meter, switch, and circuit breaker numbering.



2. COVERED STOWAGE BAGS ARE LOCATED BENEATH BOTH SEATS AND CONNECTED TO THE SEAT SUPPORT AND PLSS SUPPORT CHASSIS MOUNTS

NOTES: 1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE INDICATED

SIGNATURES	DATE
DR L. Stewart	8/10/70
DSGN Bill S. Cornelius	3-30-71
QC	1-6-72
ENGR	1-6-72
ENGR	10/2/72
APP	10-2-72
APP	
STC	10-2-72

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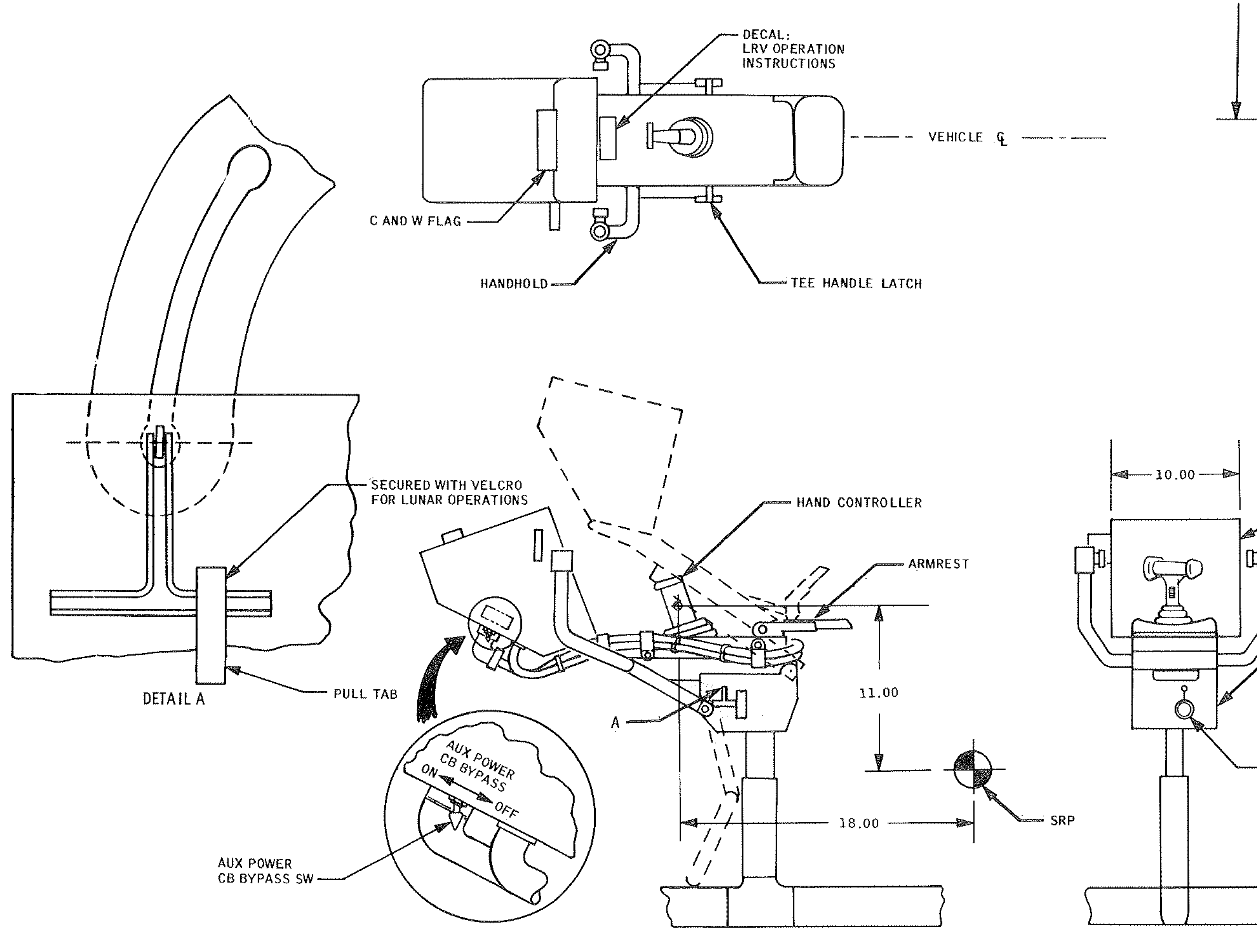
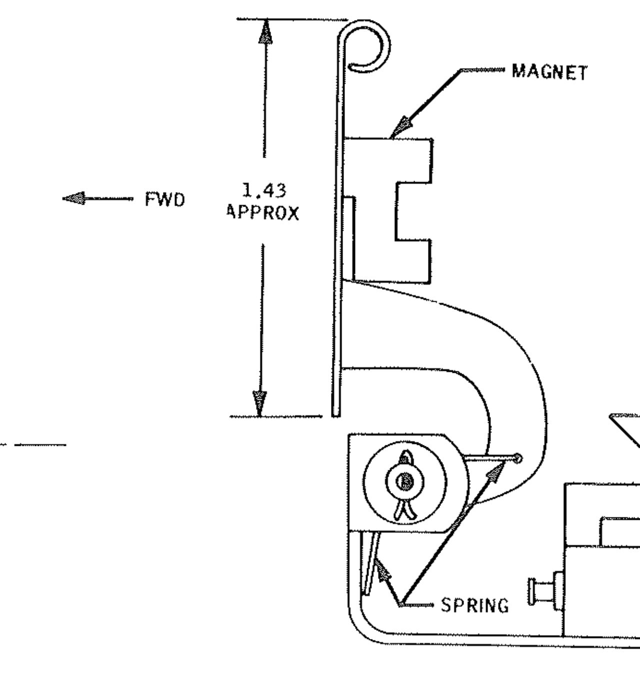
CREW STATION HARDWARE

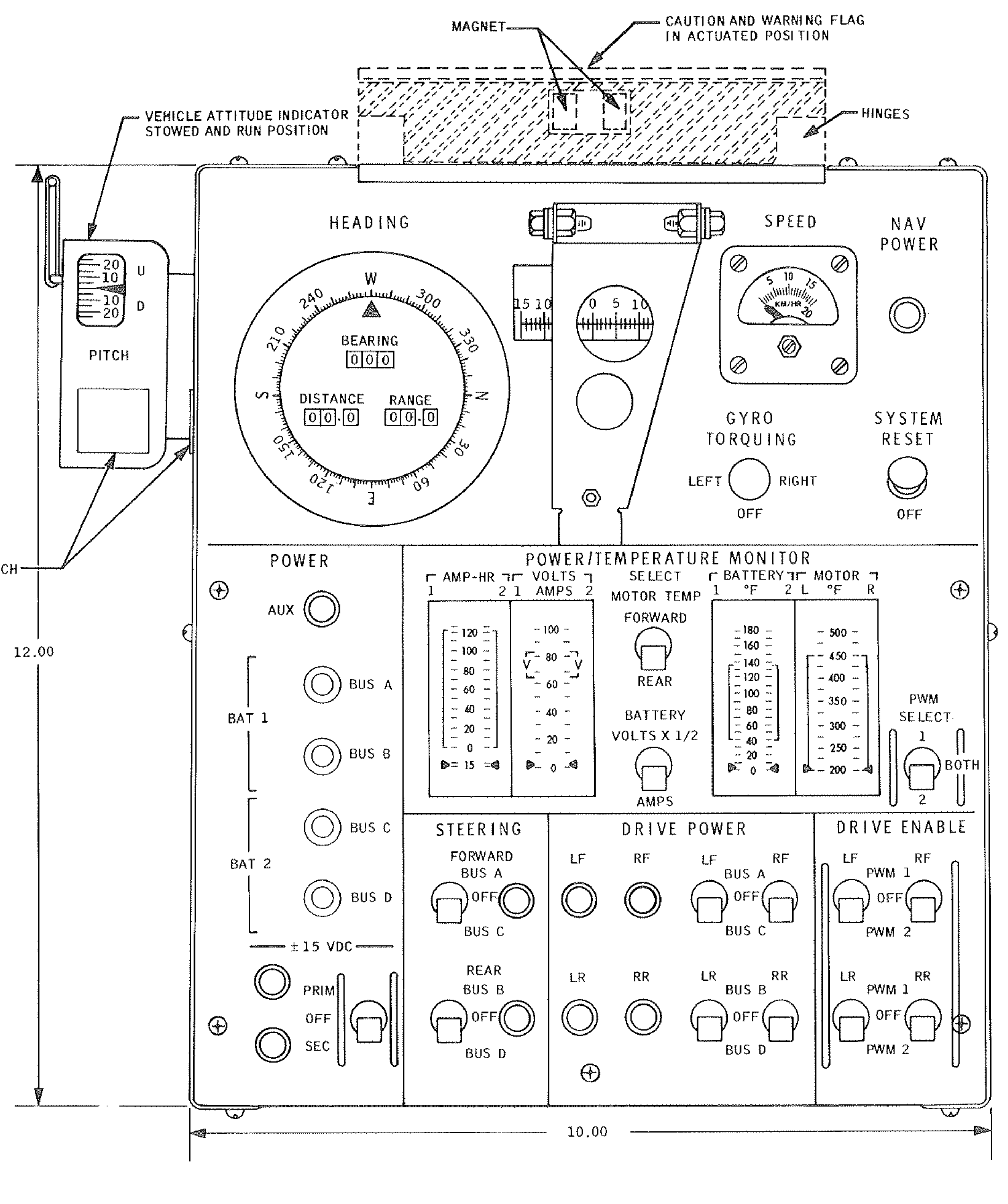
LRV
APOLLO 17
DWG NO 5.1
44 X 17
PAGE 5-10
SHEET 1 OF 1



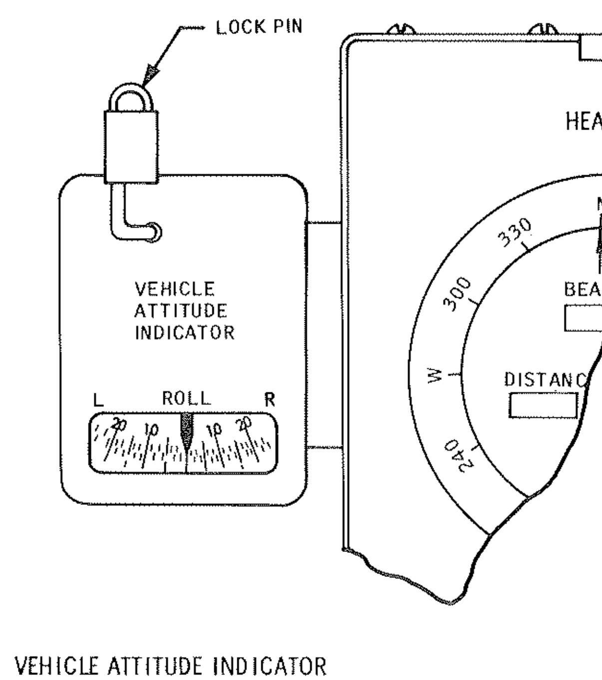
CONTROL AND DISPLAY CONSOLE - MECHANICAL



CAUTION AND WARNING FLAG DETAIL (SHOWN IN ACTUATED POSITION)



CONTROL AND DISPLAY PANEL



VEHICLE ATTITUDE INDICATOR NAV UPDATE POSITION

3. SSD SHOWN IN STORED POSITION ONLY.

2. C AND W FLAG LOCKING PIN AND ATTITUDE INDICATOR LOCKING PIN NOT SHOWN.

NOTES: 1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

LTR	PCN	DR	ENG	DATE	APPROVAL
COMMENTS:					

SIGNATURES	DATE
DR	
DSGN	
QC Betty M. Taylor	1-6-72
ENGR Peter H Cozza	1-6-72
ENGR [illegible]	10/2/72
APP Gerald D Griffith	10-2-72
APP	
STC Dean B Fisher	10-2-72

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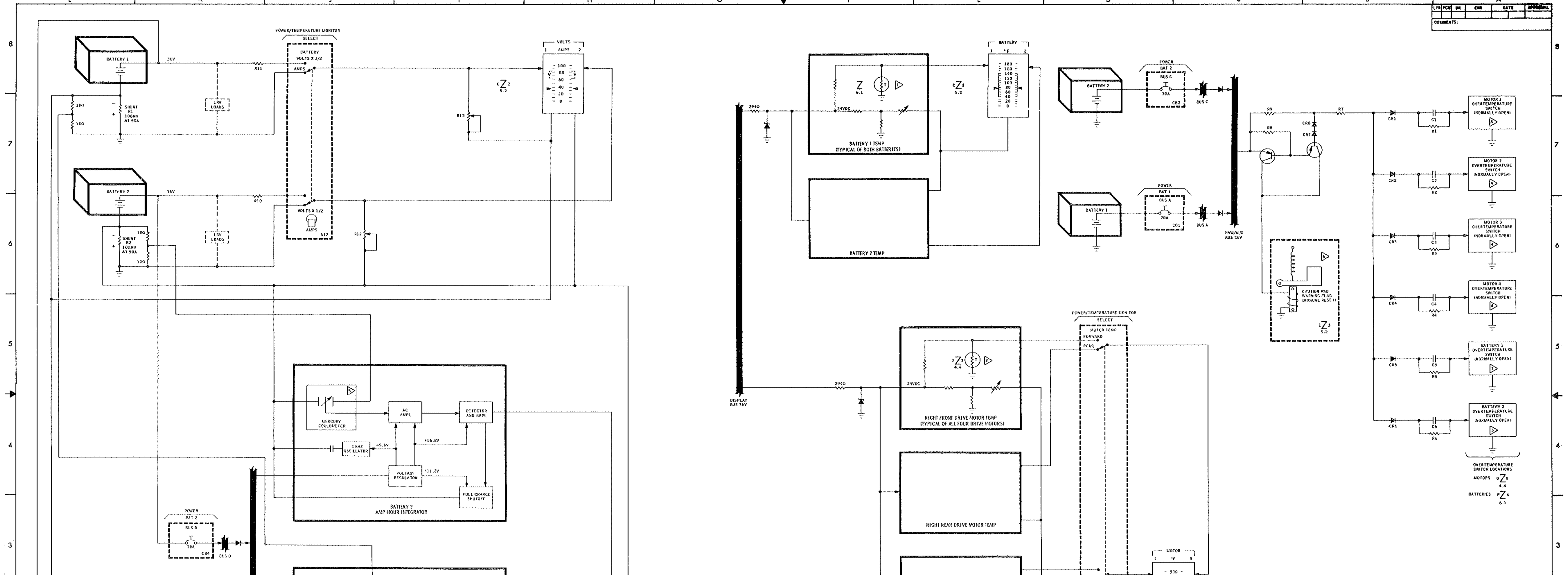
CONTROL AND DISPLAY CONSOLE

LRV	SIZE	DWG NO
APOLLO 17		5.2
44 X 17	PAGE 5-11	SHEET OF



6 FLAG IS SPRING LOADED TO RISE AND IS HELD DOWN BY A PERMANENT MAGNET. CURRENT THROUGH THE COIL (10MS, 36V PULSE) BUCKS THE PERMANENT MAGNET, ALLOWING THE FLAG TO POP UP

5 MERCURY COLUMN VARIES CAPACITANCE BETWEEN PLATES

4 MOTOR TEMPERATURE SWITCHES CLOSE AT 400° ± 12° F OPEN AT 370° ± 12° F

3 BATTERY TEMPERATURE SWITCHES CLOSE AT 125° ± 5° F OPEN AT 110° ± 5° F

2 MOTOR TRANSDUCER RANGE +150° TO +600° F

NOTES: 1 BATTERY TRANSDUCER RANGE 0° TO 180° F ±2° F FROM +20° TO 150° F

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
DR		SENSORS, DISPLAYS, AND SWITCHING
DSGN		
QC		
ENGR	1-6-72	
ENGR		
APP		LRV / APOLLO 17 — DWG NO 5.3
APP		
STC		66 X 34 — PAGE 5-12 — SHEET 1 OF 1

8. REVERSE INHIBIT SWITCH:
DOWN - INHIBITS REARWARD MOVEMENT PAST NEUTRAL OF THE PALM PIVOT BY MECHANICAL BLOCKING
UP - ALLOWS FREE MOVEMENT ABOUT PALM PIVOT

7. TO ENGAGE REVERSE POWER AFTER BRAKING, HAND CONTROLLER MUST BE RETURNED TO NEUTRAL, THEN REVERSE

6. PARKING BRAKE IS SET BY PIVOTING HAND CONTROLLER FULLY REARWARD. IT IS RELEASED BY STEERING LEFT

5. HAND CONTROLLER WILL REMAIN IN THE SELECTED FORWARD OR REVERSE POSITION AND MUST BE MANUALLY RETURNED TO NEUTRAL DRIVE POSITION

4. BRAKE EQUALIZER HAS STOP TO ALLOW FOR CABLE FAILURE BRAKING

3. HAND CONTROLLER, INCLUDING THE BRAKING SWITCHES, MOVES WITH RESPECT TO THE STRIPED FRAMES. SWITCH CAM FOLLOWER RIDES OFF THE CAM ALLOWING SWITCH TO OPEN

2. SWITCHES 1 THROUGH 8 ARE DRIVE CONTROL SWITCHES. SWITCHES ARE SHOWN IN OPEN (NEUTRAL STICK) POSITION. SWITCHES ARE CLOSED BY CAM ACTION WHEN STICK IS MOVED FORWARD OR AFT 1 DEGREE ± 0.5 DEGREES

NOTES:
1. STEERING POTS LOCATED FORWARD OF HAND CONTROLLER AND OPERATE FUNCTIONALLY AS SHOWN

SIGNATURES	DATE
DR Linda S. Diaulu	11-29-71
DSGN	
QC	1-6-72
ENGR J. F. Moser	1-6-72
ENGR	10/2/72
APP	10-2-72
APP	
STC	10-2-72

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BRAKE CABLE LAYOUT AND HAND CONTROLLER MECH/ELEC

LRV
APOLLO 17
DWG NO 5.4
68 X 22
PAGE 5-13
SHEET 1 OF 1

6 ELECTRICAL POWER

*

SECTION 6
ELECTRICAL POWER

6.1 GENERAL

The electrical power subsystem consists of two batteries and distribution wiring, connectors, switches, circuit breakers, and meters for controlling and monitoring electrical power.

6.2 BATTERIES

The LRV contains two primary silver-zinc batteries (Drawing 6.1). Both batteries are used simultaneously on an approximate-equal-load basis during LRV operation by selection of various load-to-bus combinations through circuit breakers and switches on the control display console.

The batteries are located on the forward chassis enclosed by the thermal blanket and dust covers. Battery 1 (on the left side facing forward) is connected thermally to the navigation signal processing unit and serves as a partial heat sink for the SPU. Battery 2 (on the right side facing forward) is thermally tied to the directional gyro unit and serves as a heat sink for the DGU.

The batteries are installed in the LRV on the pad at Kennedy Space Center in an activated condition and are monitored for voltage and temperature on the ground until T-18 hours in the countdown. On the lunar surface, the batteries are monitored for remaining amp-hours, temperature, voltage, and output current.

Each battery is capable of carrying the entire LRV electrical load, and the circuitry is designed such that in the event one battery fails the entire electrical load can be switched to the remaining battery.

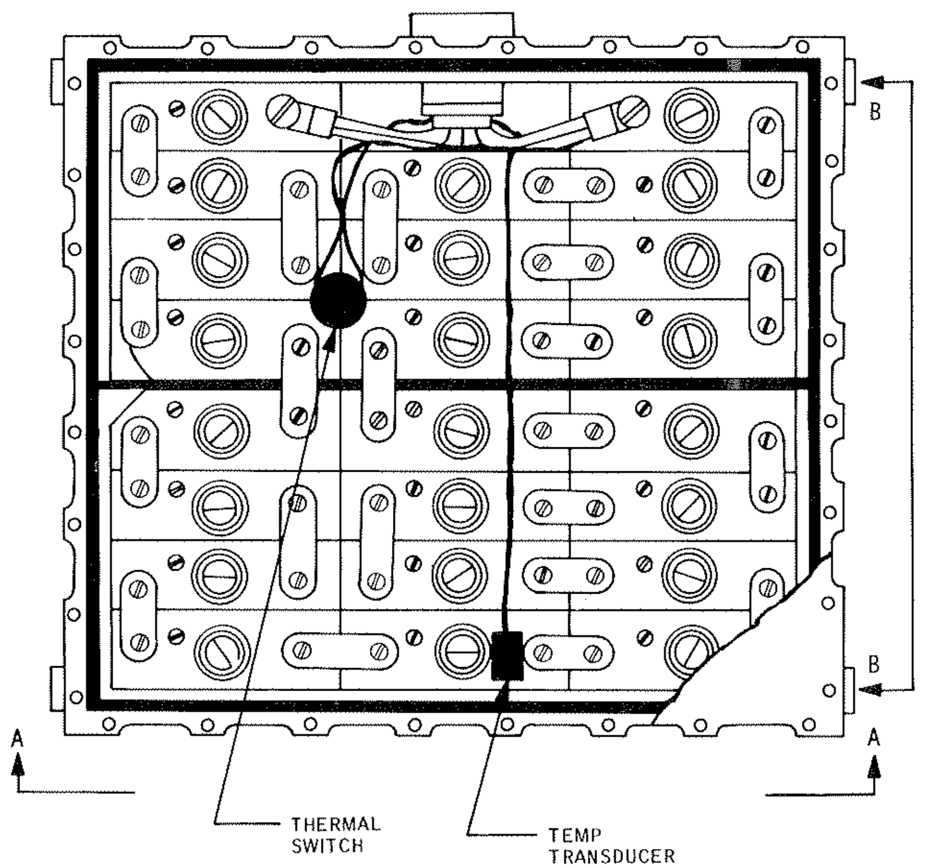
6.3 DISTRIBUTION SYSTEM

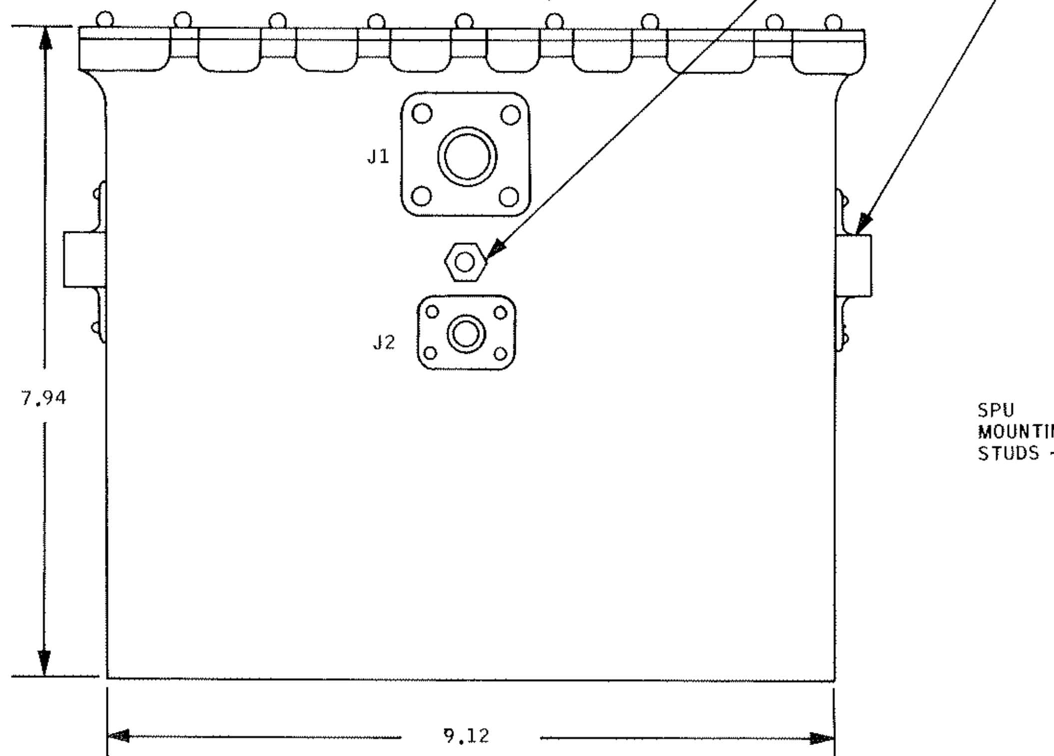
The electrical schematic for the LRV is shown in Drawing 6.2. The switch and circuit breaker arrangement is designed to allow switching any electrical load to either battery.

During normal LRV operation, the navigation system power must remain on during the entire sortie. To conserve power, all mobility elements (i.e, traction drives, steering motors, drive control electronics, and ±15 Vdc power supplies) may be turned off at a stop.

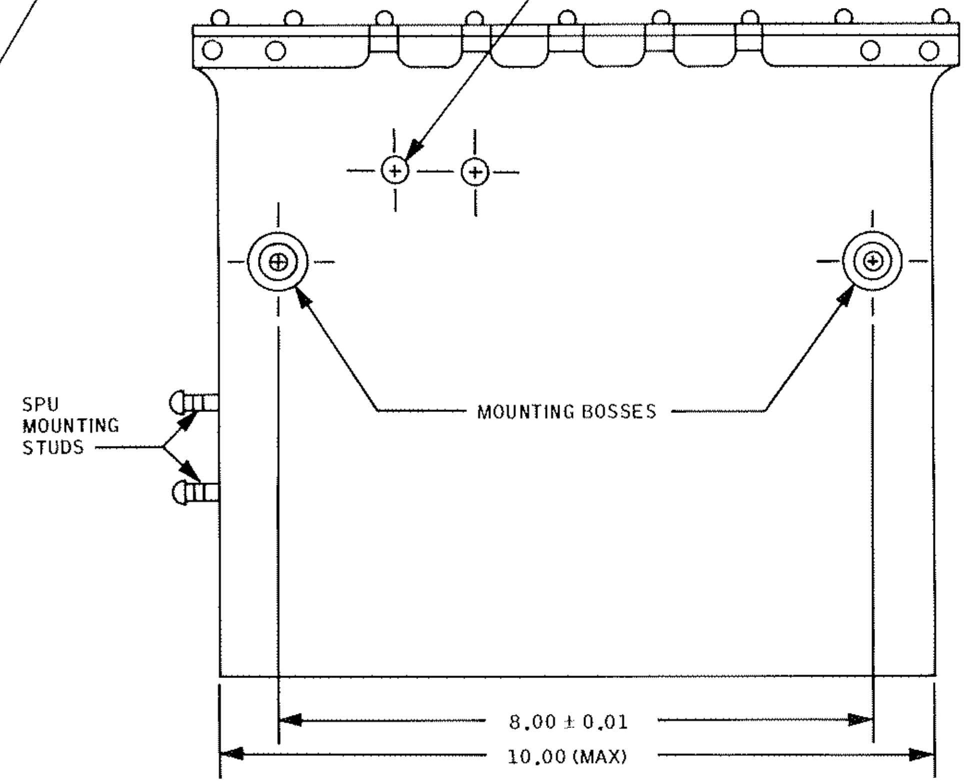
TABLE 6-I.- BATTERY DATA

Voltage:	Nominal 36^{+5}_{-3} Vdc, Transient 36^{+8}_{-4} Vdc
Current:	47 A, max peaks to 90 A
Capacity:	121 amp-hours (4356 watt-hours) at 36 Vdc nominal 115 amp-hours (4140 watt-hours) at 36 Vdc minimum
Thermal dissipation:	High thermal conductance between cell blocks and surfaces of battery case
Personnel safety:	Pressure relief valve opens at 3.1 to 7 psid, closes when differential pressure is below valve's relief pressure Case designed to withstand 9 psi (without deformation)

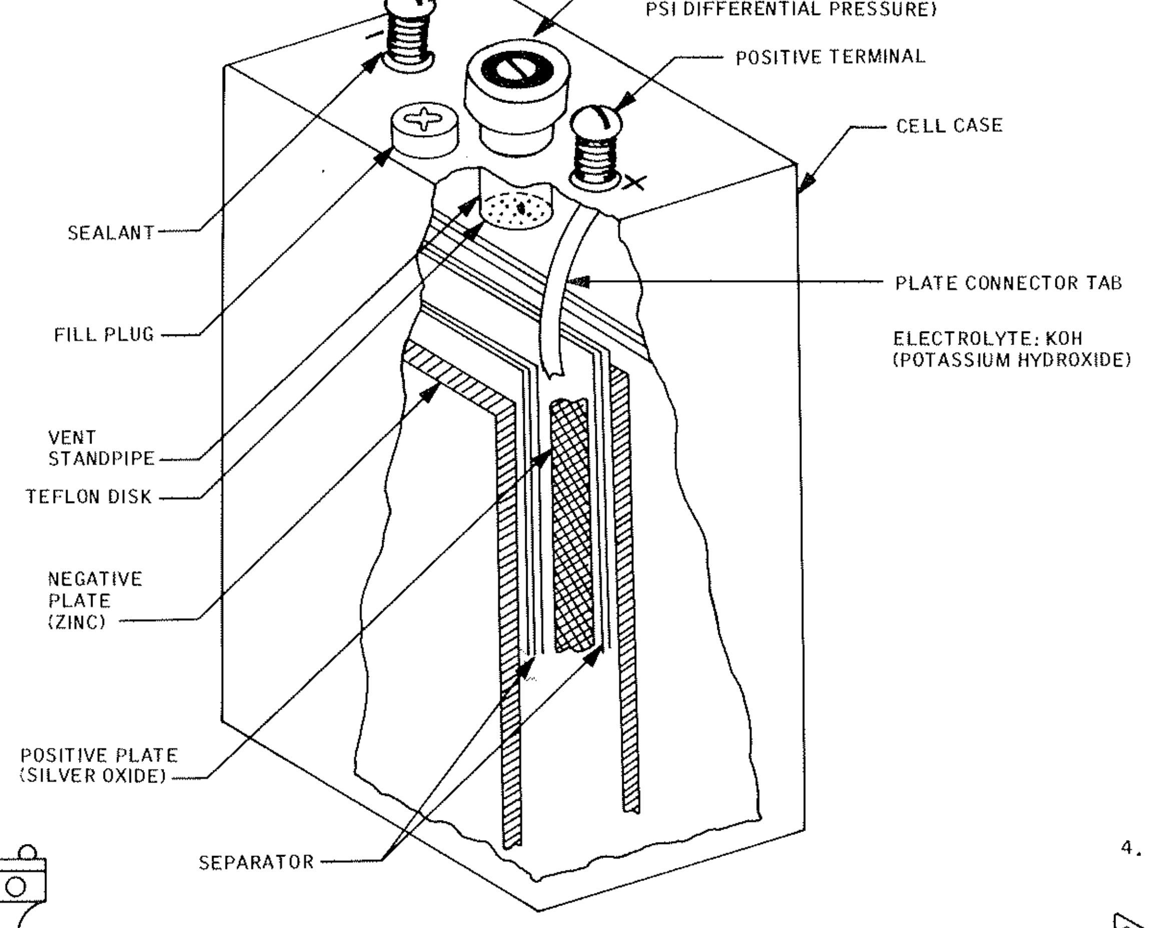




VIEW A-A



VIEW B-B



CELL DETAIL

LTR	PCN	DR	ENGR	DATE	APPROVAL

COMMENTS:

4. EACH CELL HAS A NOMINAL VOLTAGE BETWEEN 1.5 AND 1.8V

3. BATTERY CASE RELIEF VALVE OPENS AND CLOSES AT 3.1 TO 7 PSID

2. EACH BATTERY CONTAINS 23 CELLS CONNECTED IN SERIES

NOTES: 1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

SIGNATURES	DATE
DR	
DSGN	
QC [illegible]	1-6-72
ENGR [illegible]	1-6-72
ENGR [illegible]	10/2/72
APP Gerald D. Griffith	10-2-72
APP	
STC [illegible]	10/2/72

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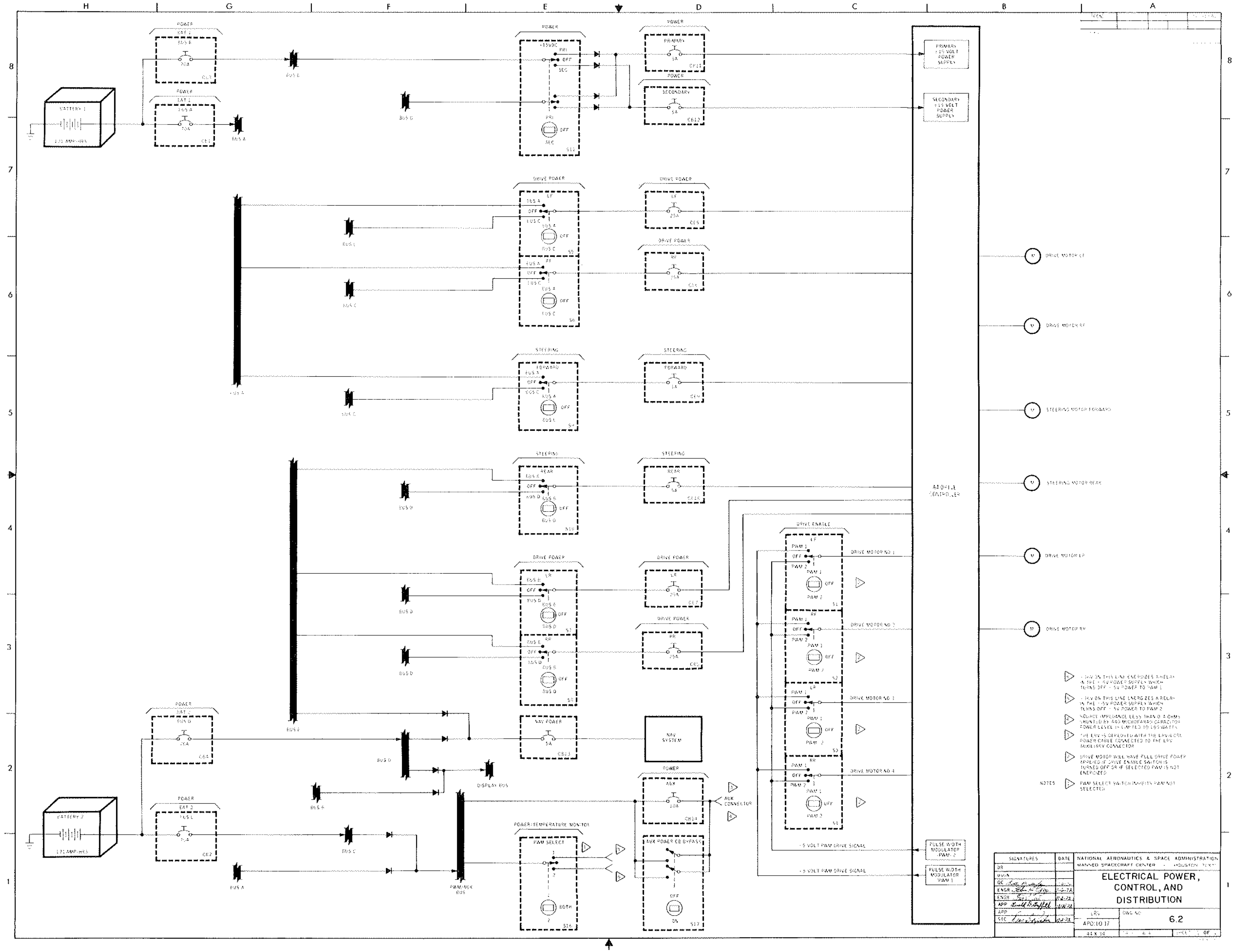
BATTERY

LRV	DWG NO 6.1	
APOLLO 16		
33 X 17	PAGE 6-3	SHEET 1 OF 1


BATTERY 1
BATTERY 2
BUS A
BUS B
BUS C
BUS D
BUS E
BUS F
POWER
DRIVE POWER
STEERING
FORWARD
REAR
DRIVE ENABLE
NAV POWER
NAV SYSTEM
AUX
AUX CONNECTOR
DISPLAY BUS
PAM/AUX BUS
POWER/TEMPERATURE MONITOR
PAM SELECT
PRIMARY +15 VOLT POWER SUPPLY
SECONDARY +15 VOLT POWER SUPPLY
PULSE WIDTH MODULATOR PAM 2
PULSE WIDTH MODULATOR PAM 1
DRIVE MOTOR RR
NOTES
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
ELECTRICAL POWER, CONTROL, AND DISTRIBUTION
APOLLO 17
6.2

7 NAVIGATION

SECTION 7
NAVIGATION

7.1 GENERAL

A block diagram of the navigation subsystem is shown in Figure 7-1. Hardware locations are shown in Figure 7-2.

The power supply converts the LRV battery voltage to the ac and dc voltages required for operation of the navigation subsystem components. Signal inputs to the subsystem are heading with respect to lunar north (which is obtained from a directional gyro) and odometer pulses corresponding to a fixed distance (which are obtained from each traction drive unit).

These signals are operated upon by the navigation subsystem which displays the results as bearing back to the LM, range back to the LM, total distance traveled, and velocity. The heading with respect to lunar north is displayed directly.

7.2 HEADING

The directional gyro is erected (case leveled) and torqued until it is aligned with lunar north. Alignment is accomplished by measuring the inclination of the LRV in pitch and roll using the attitude indicator (Drawing 5.2) and the sun angle using the sun shadow device (Drawing 5.2). This information is relayed to earth where a heading angle is calculated. The crew then torques the gyro until the heading indicator matches the calculated value. Gyro torquing can only be done continuously for 2 minutes with a 5-minute cooldown period following. This enables up to 180° azimuth change per cycle. The system is initialized by using the SYSTEM RESET switch, which resets all digital displays and internal registers to zero. Initialization is performed at the start of each traverse.

The heading angle of the LRV is derived directly from the output of the gyro, which is generated by a three-wire synchro transmitter and is independent of computed data. The heading indicator in the integrated position indicator (IPI) contains a synchro control transformer and an electromechanical servosystem which drives the control transformer until a null is achieved with the inputs from the gyro.

7.3 ODOMETER

There are four odometers in the system, one for each traction drive unit. Nine odometer pulses are generated for each revolution of each wheel. These signals are amplified and shaped in the motor controller circuitry and enter the line receiver in the SPU. The odometer pulses from only the right rear wheel enter the velocity processor for display on the LRV SPEED indicator.

Odometer pulses from all four wheels enter the odometer logic via the SPU line receivers. This logic selects the third-fastest wheel for use in the distance computation. This insures that the odometer output pulses will not be based on a wheel which is locked, nor will they be based on a wheel that is spinning.

NOTE

The odometer logic cannot distinguish between forward and reverse wheel rotation. Therefore, reverse operation of the LRV adds to the odometer reading.

The SPU odometer logic sends outputs directly to the digital distance indicator in the IPI and to the range/bearing processor in the SPU. Upon entering the range/bearing processor, the outputs initiate holding selection and conversion of heading sine and cosine to digital numbers. Low voltages (<30 volts) can cause the distance indicator to assume a random value upon resuming normal (>30 volts) voltage.

7.4 RANGE AND BEARING

The effect of conversion of heading sine and cosine at distance increments is equivalent to entering distance increment times sine heading and distance increment times cosine heading into the ΔE and ΔN registers in the digital part of the bearing and range processor. The digital processor then adds the new ΔE and ΔN numbers to the components of the east (E) and north (N) accumulators. The E and N accumulators, therefore, contain the east and north vector components of the range and bearing back to the LM. The digital vectoring process then does a vector conversion on the N and E numbers to obtain range and bearing, which are displayed on digital counters in the IPI. Each distance increment from the odometer logic initiates the entire sequence described, and results in the updating of bearing and range. Range and bearing displays will be retained in the event navigation system power is less than 30 volts, but may be lost upon return of normal power.

7.5 SUN SHADOW DEVICE

The sun shadow device is used to determine LRV heading with respect to the sun. Scale length is 15 degrees either side of zero in one-degree increments. The sun shadow device can be used at sun elevation angles up to 75°.

TABLE 7-I.- POWER REQUIREMENTS

Initialization and warmup (1.5 minutes max from closing of navigation CB)			92 watts
Operating:	DGU	12 watts	
	SPU	28	
	Display electronics	5	
	Total		45 watts

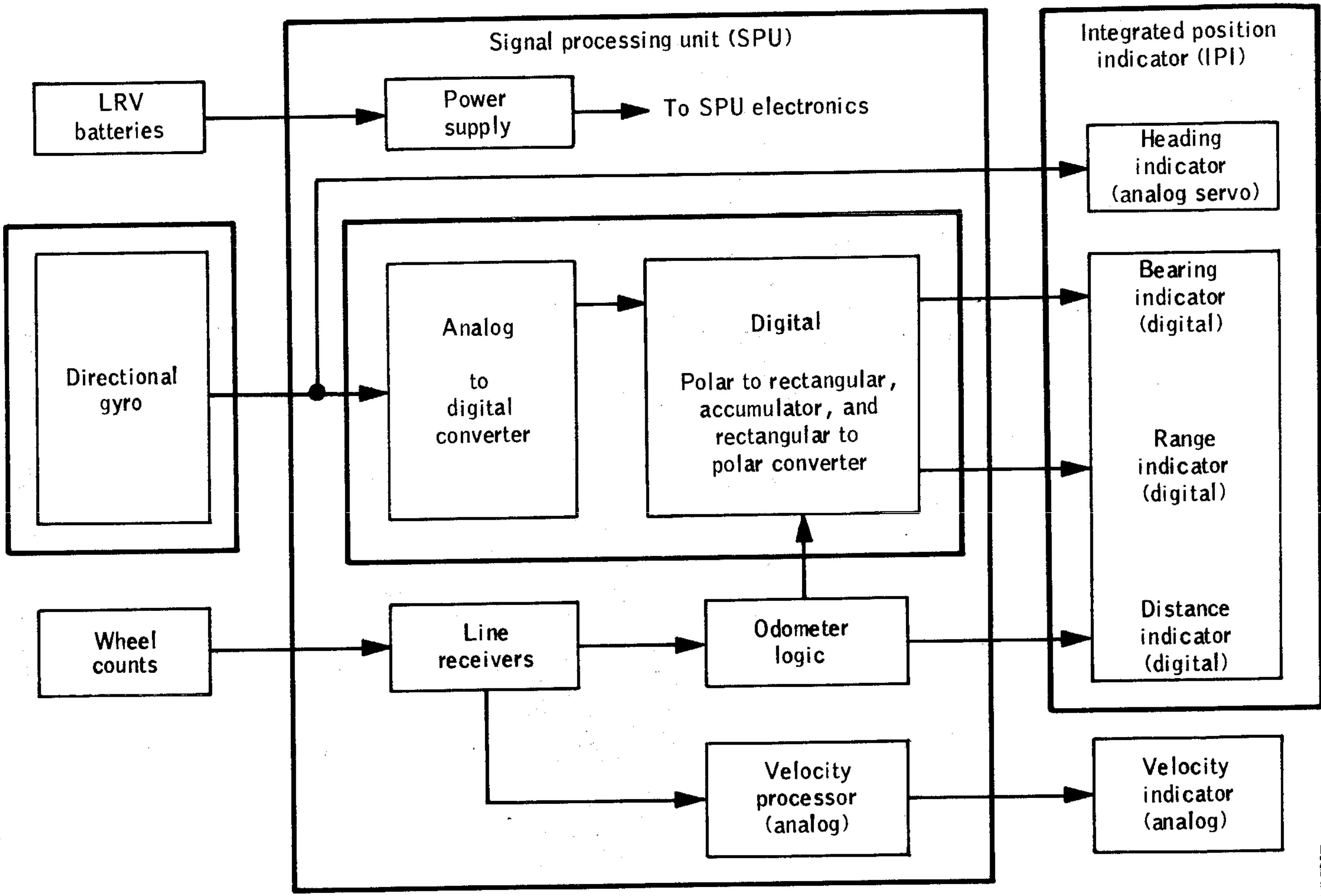


Figure 7-1. - Navigation subsystem block diagram.

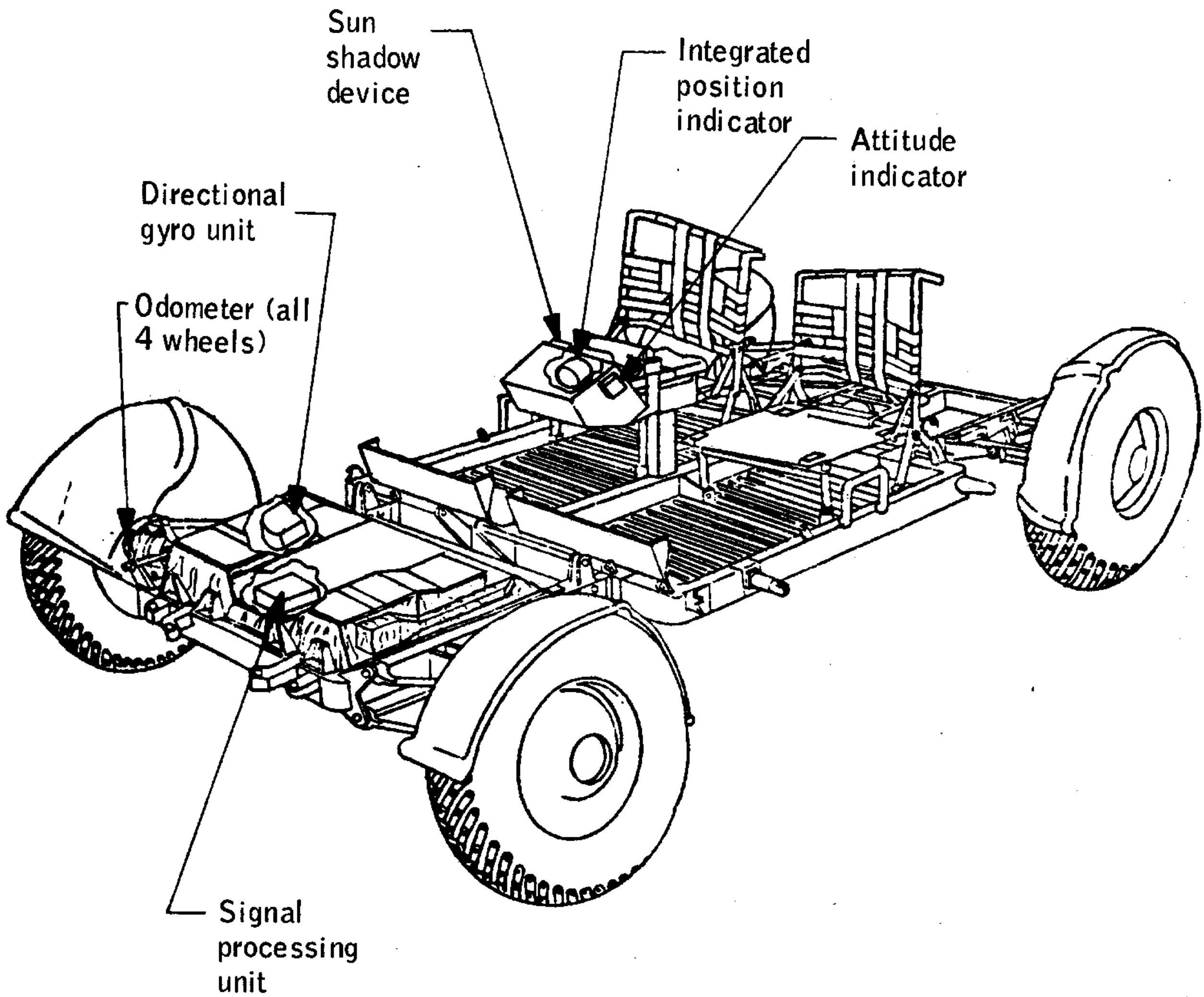
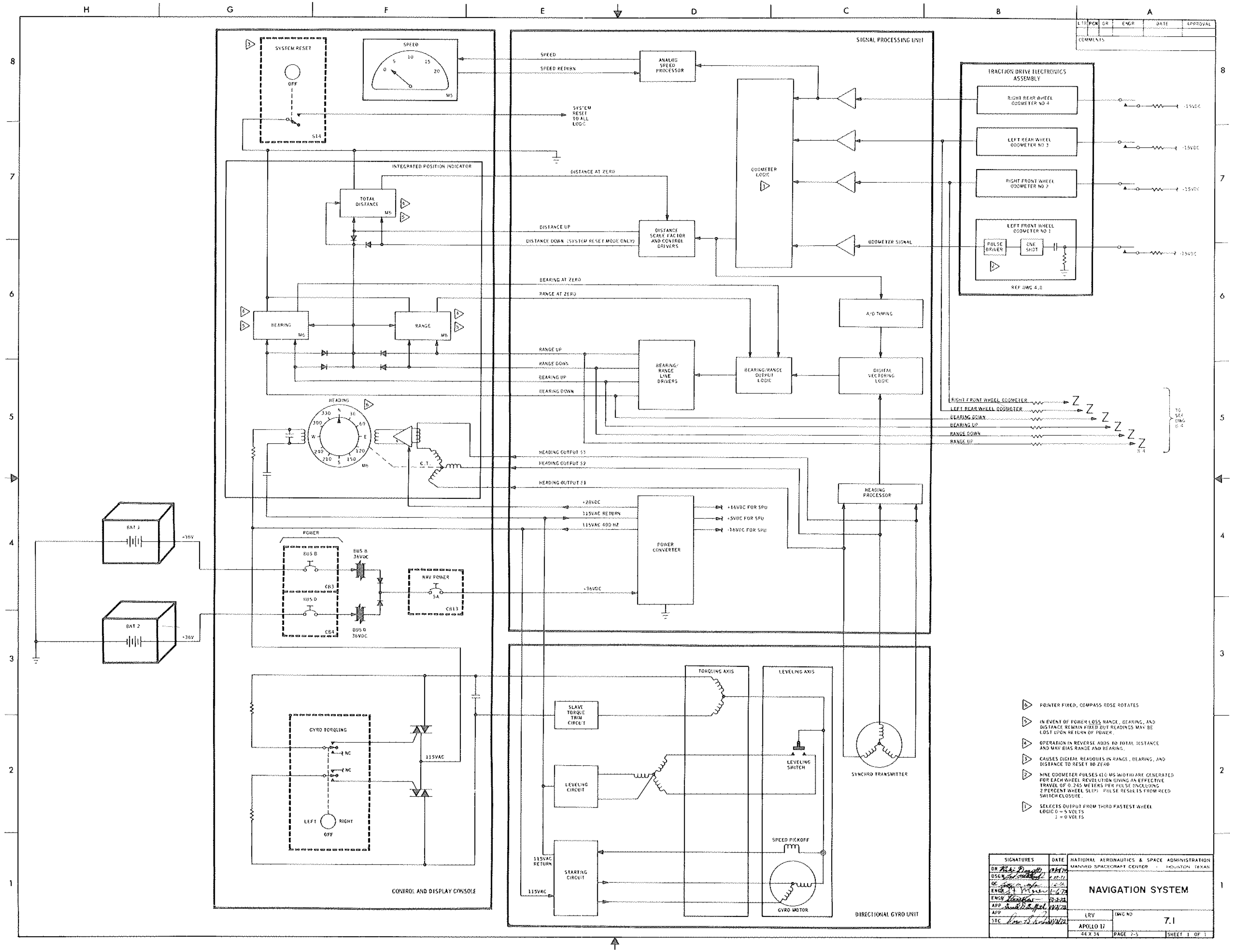


Figure 7-2. - Navigation components.



6. POINTER FIXED, COMPASS ROSE ROTATES

5. IN EVENT OF POWER LOSS RANGE, BEARING, AND DISTANCE REMAIN FIXED BUT READINGS MAY BE LOST UPON RETURN OF POWER.

4. OPERATION IN REVERSE ADDS TO TOTAL DISTANCE AND MAY BIAS RANGE AND BEARING.

3. CAUSES DIGITAL READOUTS IN RANGE, BEARING, AND DISTANCE TO RESET TO ZERO

2. NINE ODOMETER PULSES (10 MS WIDTH) ARE GENERATED FOR EACH WHEEL REVOLUTION GIVING AN EFFECTIVE TRAVEL OF 0.245 METERS PER PULSE (INCLUDING 2 PERCENT WHEEL SLIP). PULSE RESULTS FROM REED SWITCH CLOSURE.

1. SELECTS OUTPUT FROM THIRD FASTEST WHEEL
LOGIC 0 = 5 VOLTS
1 = 0 VOLTS

SIGNATURES	DATE
DR	
DSGN	
QC	
ENGR	1-6-72
ENGR	
APP	
APP	
STC	

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NAVIGATION SYSTEM

LRV
APOLLO 17
DWG NO 7.1
44 X 34
PAGE 7-5
SHEET 1 OF 1

DWG 7.2 NAVIGATION LOGIC DIAGRAM

To Be Supplied

LUNAR
SCIENCE
EQUIPMENT

DWG 8.1 TGE - MECHANICAL

To Be Supplied

DWG 8.2 TGE - ELECTRICAL

To Be Supplied

DWG 8.3 APOLLO LUNAR SURFACE DRILL
AND ANCILLARY EQUIPMENT

To Be Supplied

DWG 8.4 SEP - MECHANICAL

To Be Supplied

DWG 8.5 SEP - ELECTRICAL

To Be Supplied

LUNAR
MODULE
INTERFACE

SECTION 9

LRV DEPLOYMENT MECHANISM SPACE SUPPORT EQUIPMENT (SSE)

9.1 PERFORMANCE

The LRV Deployment Mechanism is required to support and restrain the stowed LRV in the Quadrant I stowage bay of the LM during earth-lunar transit, and to deploy the stowed vehicle to the lunar surface. The SSE is required to deploy the LRV within 15 minutes with the LM tilted up to 14-1/2 degrees in any direction and with the bottom of the descent stage 14 to 62 inches above the lunar surface. LRV deployment manual activity is normally performed by both crewmen.

9.2 EQUIPMENT DESCRIPTION

The Deployment Mechanism consists of two basic subsystems of hardware, the structural support subsystem and the deployment hardware subsystem. The function of the structural support subsystem is to structurally support the LRV in the LM during launch boost, earth-lunar trasit and landing. The function of the deployment hardware subsystem is to deploy the LRV from the LM to the lunar surface after landing.

9.2.1 Structural Support Subsystem

The structural support subsystem includes two steel SUPPORT SPOOLS at the lower (left and right) sides of the LM quadrant. The spools are bolted to support arms (walking hinge members). Aluminum tube tripod structure attached to the LRV center chassis terminate in left and right tripod apex fittings which attach to the support spools. The apex fitting halves are pinned together and clamped to the spools to support the LRV. The LRV is restrained against outboard rotation by an aluminum strut (the UPPER SUPPORT ARM) in the upper center of the LM, connecting the inboard quadrant corner structure to an LRV center chassis standoff with a pin.

9.2.2 Deployment Hardware System

The deployment hardware system (Figure 9-1, sheet 1) consists of bellcranks, linkages and pins to release the LRV from the structural subsystem, thus allowing the LRV to deploy from the LM. It also consists of braked reels, braked reel operating tapes, braked reel deployment cables, LRV rotation initiating push-off spring, telescopic tubes, chassis latches, release pin mechanisms, and LRV rotation support points, all of which operate in the following manner and sequence.

9.3 LRV DEPLOYMENT

The deployment of the LRV from the LM to the lunar surface consists of the following five basic phases:

Phase I - Deployment from the stowed position of both left and right braked reel operating tapes (left and right reel ops tapes) and the deployment lanyard.

Phase II - Operating the D-ring to disconnect the LRV from the structural support subsystem.

Phase III - Operating the right braked reel to unfold the LRV and lower the aft chassis wheels to the lunar surface.

Phase IV - Operating the left braked reel to lower the forward chassis wheels to the lunar surface.

Phase V - Disconnecting the deployment hardware from the LRV after all four wheels are on the surface.

NOTE

Prior to Phase I the thermal blanket must be pulled and pre-deployment inspection accomplished. Special consideration should be given to the walking hinges to assure they are both latched, with the latching arm securely against the dog and the visible white stripe aligned.

9.3.1 Phase I

Phase I consists of deployment of the two braked reel operating tapes and the deployment lanyard from their stowed positions. The right braked reel operating tape is stowed in a nylon bag attached to the lower right support arm by velcro tape. The left braked reel operating tape is stowed on the left side of the LRV center chassis in a nylon bag attached to the lower left support arm by velcro tape. (See Figure 9-1, sheet 1, K/2.) The deployment lanyard is stowed on the left side of the LRV center chassis by teflon clips. The deployment lanyard is used to assist deployment of the LRV if it stops during any phase of the deployment.

9.3.2 Phase II

At the completion of Phase I, the astronaut pulls the D-ring, which is located on the right side of the porch. The first 5-6 inches of travel of the D-ring removes the two lower release pins (Detail C) from the apex fittings, releasing the lower halves and allowing them to fall away immediately or during deployment rotation. The apex fittings are now configured to lift off the support spools when required. The last segment of travel of the D-ring removes the upper release pin (Detail A). When the upper release pin is removed, the push-off spring rotates the LRV out from the LM approximately 4°, taking up the slack in the outer deployment cables (outrigger cables).

9.3.3 Phase III

The LRV is now released from the LM and is ready to be deployed to the lunar surface. During the entire Phase III operations, the astronaut operates the right BRAKED REEL OPERATING TAPE. The braked reel is a worm and wheel gear arrangement. When the operating tape is pulled, the cable storage drum rotates feeding off cable from the drum (Detail B). The cable is attached to the LRV center chassis and, as the LRV rotates outboard due to gravity, the cable resists the motion of the LRV due to the gearing of the braked reel. As the drum is rotated, feeding out cable, the LRV is allowed to rotate and deploy. For the first 15° of rotation, the LRV rotates on the apex fittings. At 15° of rotation, the support arm is engaged by the LRV and the point of rotation shifts from the apex fittings to the support arm, at which point the apex fitting lifts off the support spools. The deployment lanyard may or may not be required at this time, depending on the landing attitude of the LM.

The LRV continues to rotate about the support arm. At 35° rotation, the lower telescopic tube ratchets are engaged, preventing any reverse rotation of the telescopic tube assembly about its lower pivot points. The telescopic tube assembly consists of three telescoped aluminum tubes, hinged to the LM structure (lower center of the LM quadrant) and connected at the top by the saddle. The aluminum saddle fits to the forward section of the forward chassis, held by two dowel pins and a ball-lock pin clevis joint. The saddle carries the pulleys, cables and pin mechanisms whereby the forward and aft LRV chassis are unlocked from the stowed (folded) LRV position. As the LRV moves outboard, the 45° cable tightens, and rotates the saddle pulley (Detail E). This rotation actuates (rotates) two additional pulleys, each with a steel cable and ball-lock pin. The two ball-lock pins lock the connection between forward and aft chassis to the console post mounted on the center chassis. If either the aft or forward chassis latch pin fails to pull, the deployment lanyard may be pulled to help accomplish this action or the latch pins may be manually pulled by utilizing the LRV contingency tool.

The telescopic tubes and forward chassis stop at 45° due to the 45° center cable (chassis latch actuating cable) becoming taut; then, by counteracting forces of the LRV forward chassis hinge torsion spring, the telescopic tubes and forward chassis return to the 35° position (stop due to the telescopic tube ratchet). The center chassis and aft chassis continue to deploy. After it is unlocked, the aft chassis fully deploys (unfolds) automatically due to the aft chassis hinge torque bars, until it latches with the center chassis.

The wire mesh LRV wheels are held in the stowed position by four wheel lock struts. One end of each strut is held by a steel wheel lock strut PIN to the aft or forward chassis structure. The other end of each strut is held to the wheel hub by a pin (in the hub). The wheel lock strut pins are pulled by a steel cable so linked as to pull the pins as the aft or forward chassis opens approximately 170°. When the pins are pulled, the spring-loaded wheels deploy to the operational position. As the wheels rotate outboard to the deployed position, a mechanism within the wheel hub retracts the pin retaining the wheel strut. The strut is thus freed at both ends, and falls free during wheel deployment movement. Each strut is retained by a 1/8 inch diameter mylar tether.

The LRV center/aft chassis continues outboard rotation, pivoting around the lower support arm latch. During LRV outboard rotation, the telescopic tubes extend (lengthen). Before 72° LRV rotation an anti-collapse telescopic tube latch in each tube engages to prevent shortening (but permit elongation of tubes).

At approximately 73° center chassis angle, the cam on the forward sides of the center chassis strut (engaged in the lower support arm latch) strikes the steel latch arm (Detail D). As the chassis rotates, the cam forces the latch lock arm down out of a safety retaining spring, and unlocks the latch. The center/aft chassis continues to rotate until the aft chassis wheels are on the surface. The wheels are locked with the emergency hand brake and therefore must slide on the surface. Depending on the landing attitude of the LM and the condition of the surface, the wheels might not slide on the lunar surface, therefore use of the deployment lanyard by the astronaut would be required. The astronaut continues to actuate the right braked reel operating tape to allow the forward chassis hinge to deploy by virtue of the forward chassis hinge torsion spring. Concurrently, the center/aft chassis moves outboard, away from the LM. At this point in the sequence, the 45° (center) CABLE becomes taut due to the outboard movement of the entire LRV. The center chassis continues to move down but is driven outboard by the forward chassis springs. As the angle between forward and center chassis approaches 170°, the forward wheel lock strut pins in the forward chassis release and the forward wheels deploy as did the aft wheels. The astronaut then pulls the pins that attach the two outer braked reel deployment cables (outrigger cables) to the center chassis.

Phase III is complete (motion ceases) with the aft wheels on the lunar surface, with forward and aft chassis locked to the center chassis, all wheels deployed, all four wheel struts free and hanging from their tethers, the outer braked reel deployment (outrigger) cables released, and with the forward chassis held up by the telescopic tube assembly and the 45° (center) cable.

9.3.4 Phase IV

This phase of the deployment consists of the astronaut actuating the left BRAKED REEL OPERATING TAPE, thus allowing the forward wheels to lower to the surface. Again, the deployment lanyard may be required at this point if the aft wheels will not slide on the surface.

NOTE

The left braked operating tape must be pulled until slack exists in the 45° (center) cable to insure saddle release.

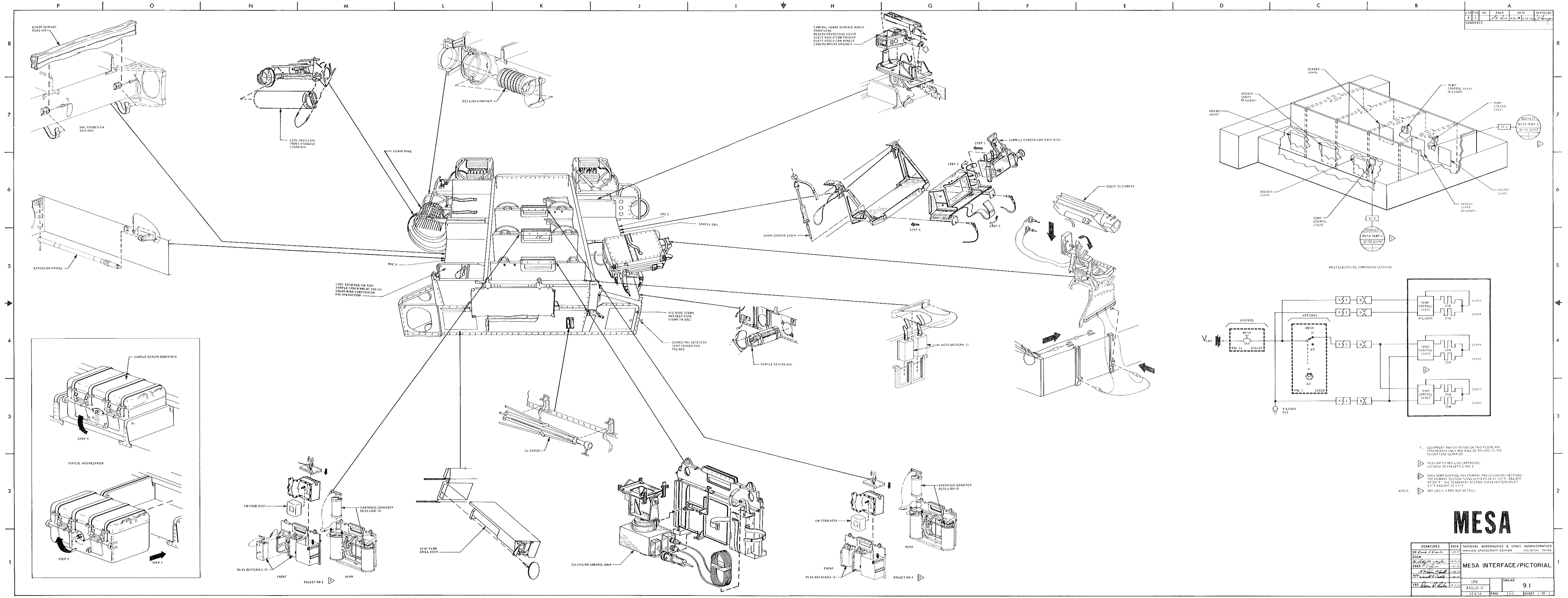
9.3.5 Phase V

This phase consists of releasing the deployment hardware from the LRV. The astronaut pulls up on the saddle release cable located on the left rear side of the forward chassis. This operation releases a ball-lock pin which holds the saddle on the forward chassis (Detail F). When the saddle is released the following hardware goes with it:

- Telescopic tube assembly
- Forward and aft chassis lock relase pins
- Forward chassis wheel lock struts and tethers

The astronaut then pulls a ball-lock pin, located on the aft center of the aft chassis. This releases the deployment lanyard and the aft chassis wheel lock struts (Detail G).

At this point, the deployment of the LRV from the LM to the lunar surface is complete.



NOTES

1. SEE DWG 9.9 FOR INST DETAILS
2. EACH TEMP CONTROL HAS PRIMARY AND SECONDARY SECTIONS. THE PRIMARY SECTION TURNS HEATERS ON AT 50° F, AND OFF AT 55° F. THE SECONDARY SECTION TURNS HEATERS ON AT 50° F AND OFF AT 60° F
3. PLSS BATTS AND LiOH CARTRIDGES LOCATED ON PALLETS 1 AND 2
4. EQUIPMENT AND LOCATIONS ON THIS FIGURE ARE PRELIMINARY ONLY AND WILL BE REVISED TO THE FLIGHT CONFIGURATION

MESA

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
DR		MESA INTERFACE/PICTORIAL
DSGN		
QC		
ENGR		
APP		
FEC		
		LRV — APOLLO 17 — DWG NO 9.1
		PAGE 13-1 — SHEET 1 OF 1

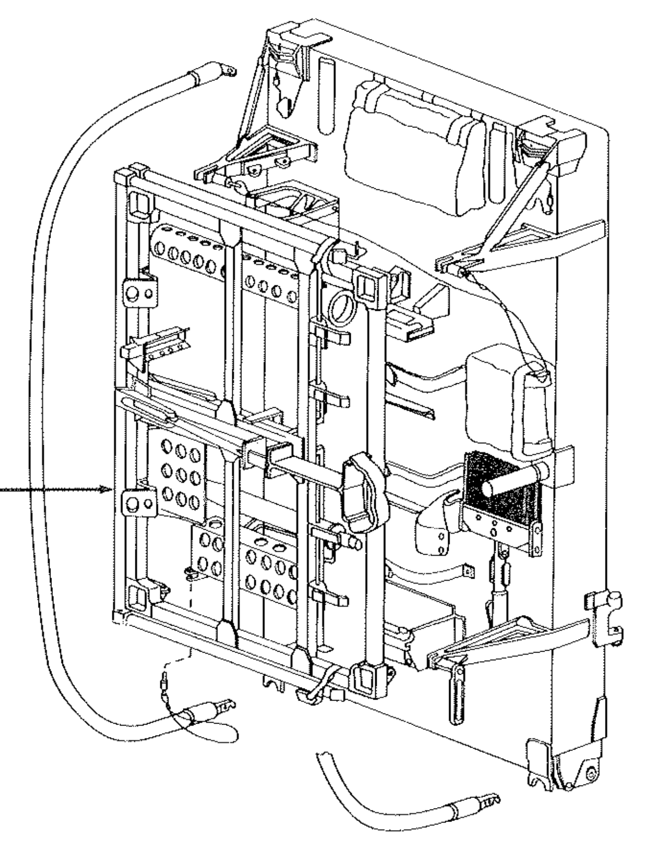
ALSEP-QUAD III

QUAD III PALLETS
(LAUNCH CONFIGURATION)

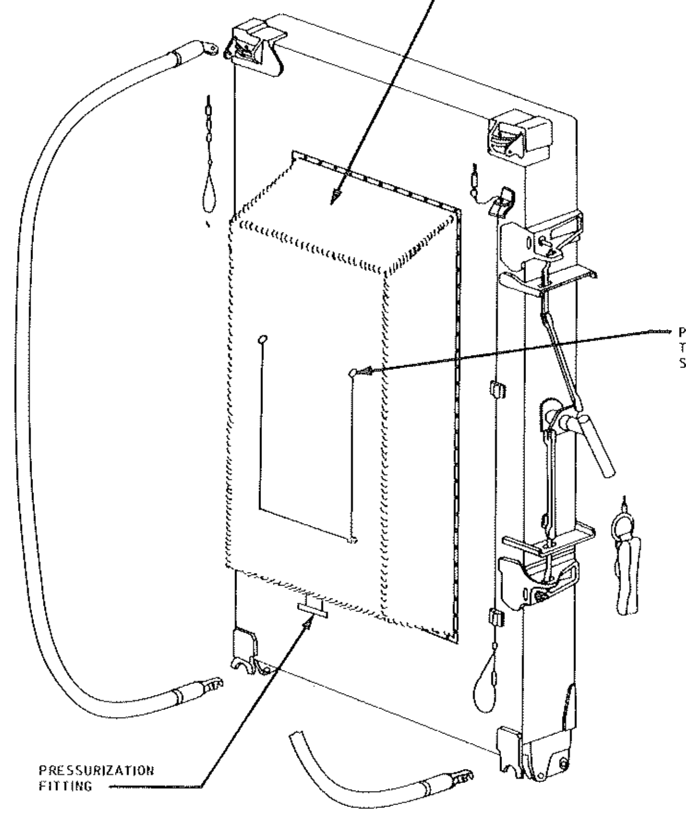
ON PALLET

BAG, LUNAR SURFACE SAFETY LINE
- 100 FOOT SAFETY LINE
- LENS BRUSH
- LUNAR DUST BRUSH
- SAMPLE COLLECTION BAGS
- SELF RECORDING PENETROMETER ASSY
- PENETROMETER UPPER HOUSING ASSY
- PENETROMETER RETURN COVER
- PENETROMETER HOLDER ASSY
- DRILL STRING VISE

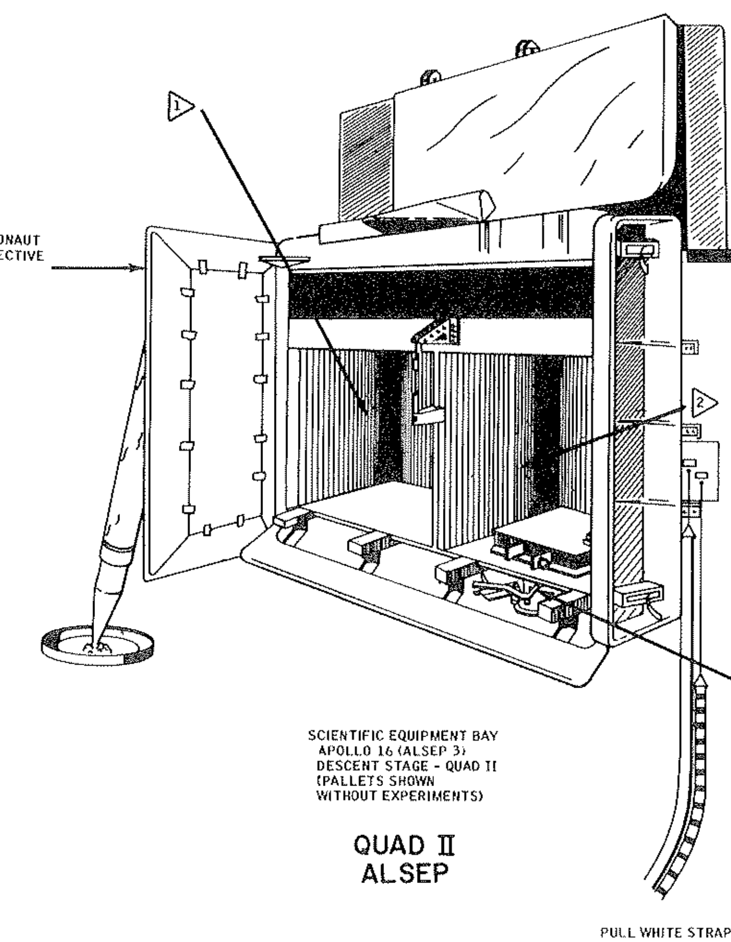
LUNAR HAND TOOL CARRIER
- EXTENSION TOOL
- TONGS
- GNOMON
- ADJ SAMPLING SCOOP
- HAMMER
- 20 BAG DISPENSER
- CORE TUBES
- CORE TUBE CAP DISPENSER
- SPECIAL ENVIRONMENT SAMPLE CONT
- DRILL STEMS
- DRILL STEM CAPS AND RETAINERS



LVR AFT PALLET



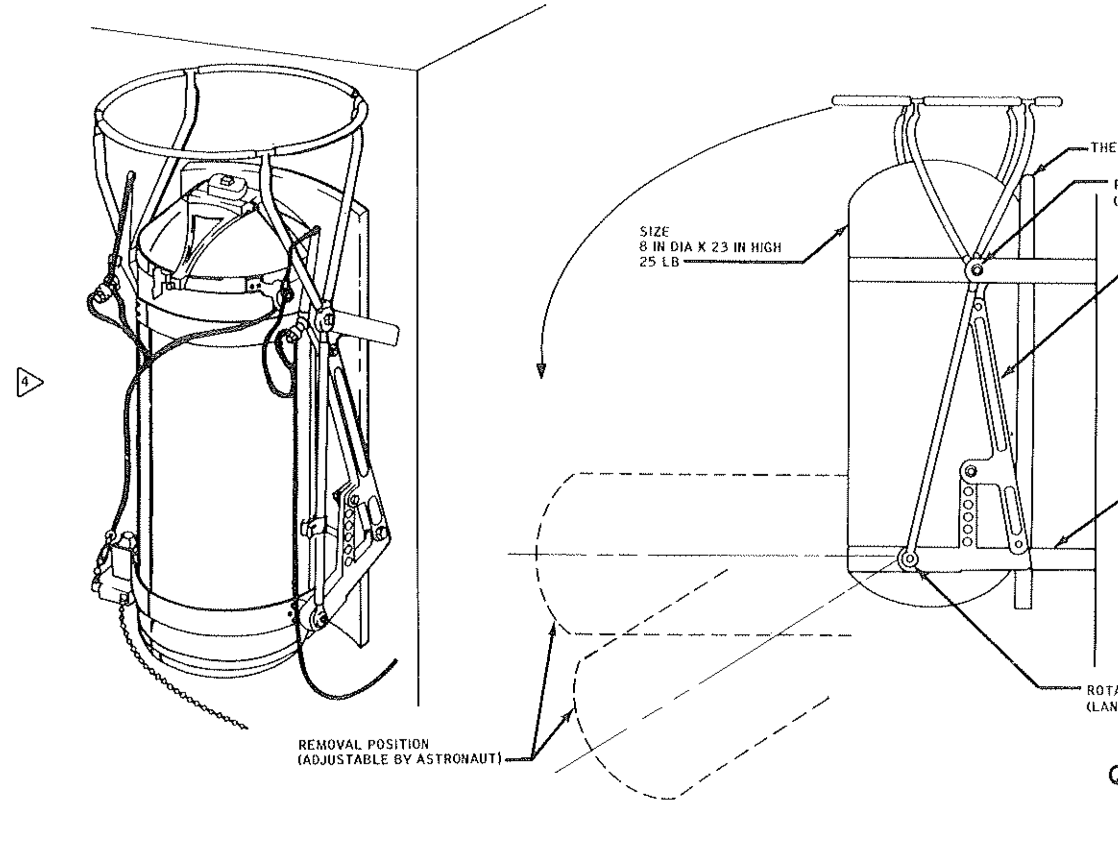
PAYLOAD PALLET
UV CAMERA



SCIENTIFIC EQUIPMENT BAY
APOLLO 16 (ALSEP 3)
DESCENT STAGE - QUAD II
(PALLETS SHOWN
WITHOUT EXPERIMENTS)

QUAD II ALSEP

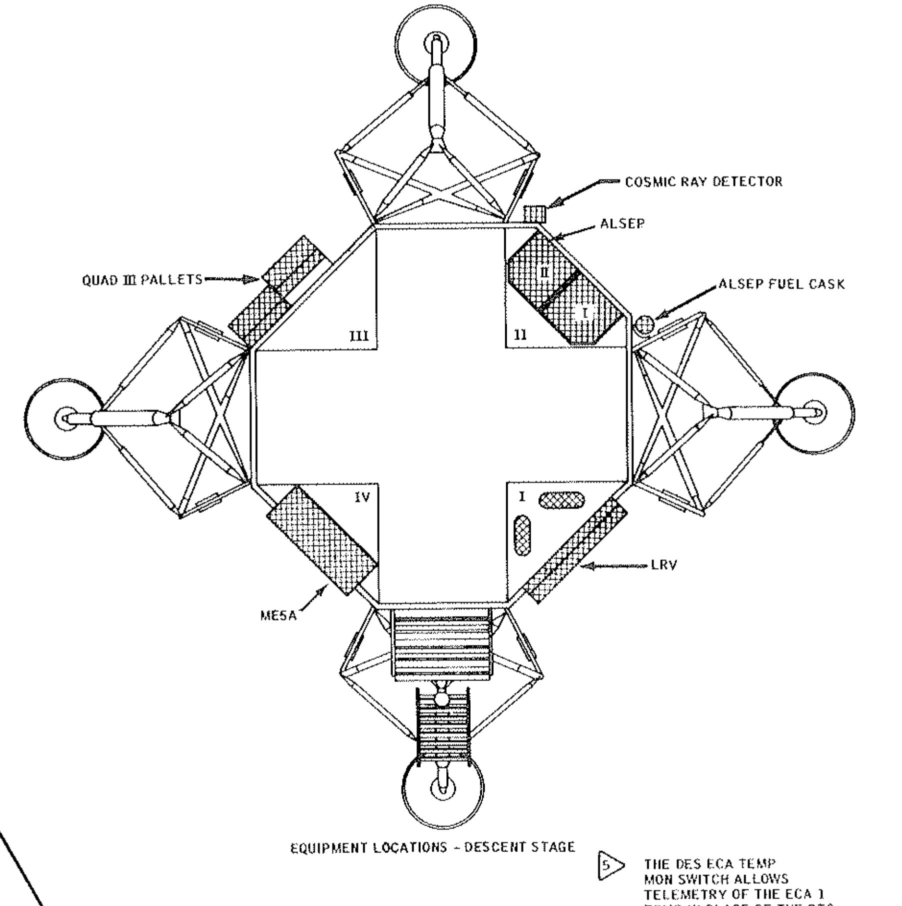
PULL WHITE STRAP TO OPEN DOORS
STRIPED STRAP TO CLOSE.
FAR LEFT DOOR SWINGS OPEN FIRST,
THEN DOUBLE DOORS RETRACT UPWARD.
DOORS CLOSED AFTER PACKAGE REMOVAL
TO MAINTAIN THERMAL CONTROL.



ALSEP FUEL CASK IN FLIGHT POSITION

QUAD II RTG

DES ECA
TEMP MON
ON
OFF
5



EQUIPMENT LOCATIONS - DESCENT STAGE

NOTES:

1. SUBPACKAGE I CONSISTS OF:
   1. PASSIVE SEISMIC EXPERIMENT
   2. ACTIVE SEISMIC EXPERIMENT
   3. LUNAR SURFACE MAGNETOMETER
   4. CENTRAL STATION
2. SUBPACKAGE II CONSISTS OF:
   1. HEAT FLOW EXPERIMENT
   2. RTG
   3. ALSEP TOOLS
3. SEE ALSEP SYSTEMS HANDBOOK FOR TECH DATA
4. INST ON FUEL CASK IS COMPOSED OF 2 THERMOCOUPLES. GL8275 ON THE DOWNLINK COVERS BOTH MEASUREMENTS. THE THERMOCOUPLE ON THE CASK IS ACTIVE UNTIL INST IS SHUT OFF ON THE PAD. A BAROMETRIC SWITCH ACTUATED AT 10,000 FEET SWITCHES TM TO THE SHIELD THERMOCOUPLE
5. THE DES ECA TEMP MON SWITCH ALLOWS TELEMETRY OF THE ECA 1 TEMP IN PLACE OF THE RTG CASK/SHIELD TEMP

LTR	PCN	DR	ENGR	DATE		APPROVAL
A	2		S.U. Lune	3-20-72	3-20-72	J.E. Hannigan
COMMENTS						

SIGNATURES	DATE
DR Malcolm D. Scott	4-7-71
DSGN	
QC	4-15-71
ENGR	4-15-71
	4-15-71
APP Donald K. Slayton	4-15-71
FEC	4-15-71
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

ALSEP-QUAD III
INTERFACE

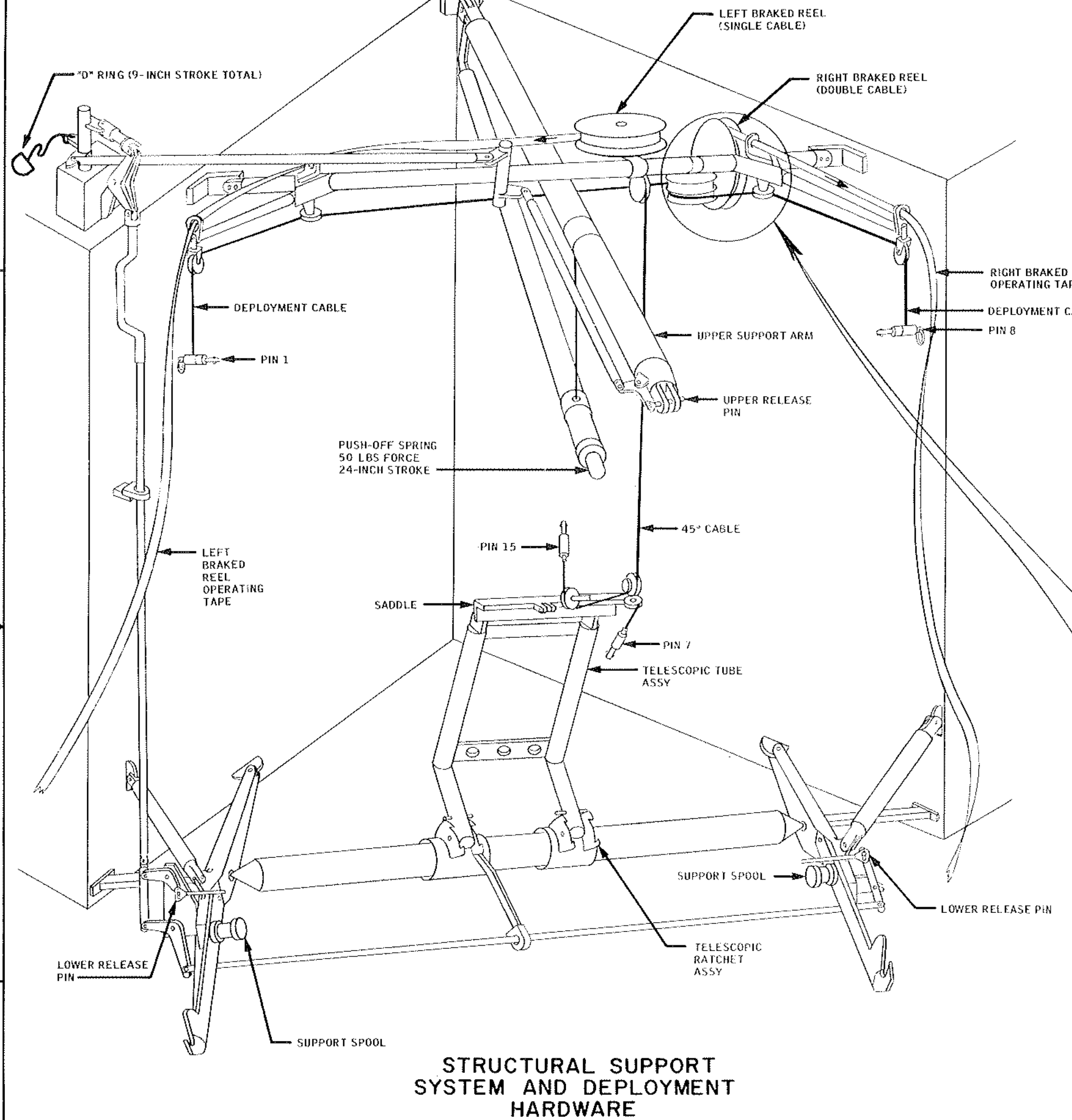
LRV
APOLLO 17
64 X 23.75

SIZE J | DWG NO 9.2 | PAGE 9.7 | SHEET 1 OF 1

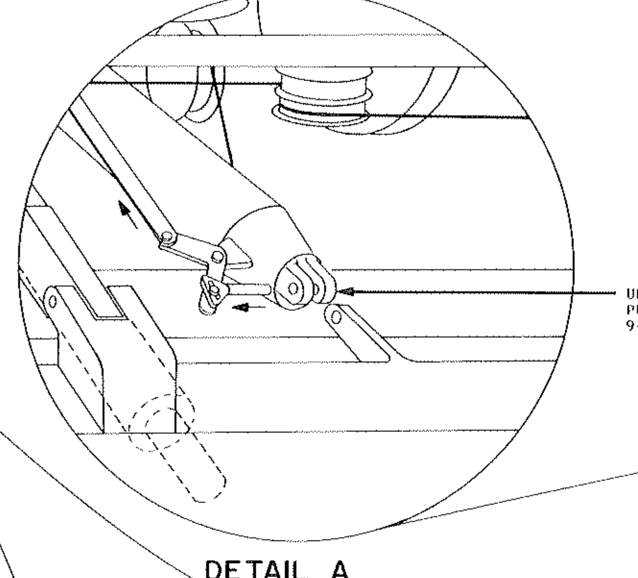
DEPLOYMENT SEQUENCE

1. PULL "D" RING
2. LOWER RELEASE PINS (2) ARE PULLED AND LOWER HALF OF APEX FITTINGS (2) ARE RELEASED (DETAIL C)
3. UPPER RELEASE PIN PULLED, LRV NOW FREE TO ROTATE 4° (DETAIL A)
4. PULL RIGHT BRAKED REEL OPERATING TAPE, (DETAIL B)
5. DEPLOYMENT CABLES (2) PLAY OUT ROTATING LRV 15°
6. LRV CAM LATCHES IN SUPPORT ARM (WALKING HINGE)
7. APEX FITTING LIFTS OFF SPOOLS (2) AT 16°
8. PUSH OFF SPRING APPLIES FORCE TO LRV THRU THE FIRST 24° OF TRAVEL
9. TELESCOPIC TUBE ASSY AND RATCHET ASSY ENGAGE PRIOR TO 40° TO PREVENT REVERSE ROTATION
10. 45° CABLE TIGHTENS, ROTATING SADDLE PULLEY WHICH ROTATES TWO SMALLER PULLIES RELEASING THE FORWARD AND AFT CHASSIS RELEASE PINS. (DETAIL E)
11. THE AFT CHASSIS IS FREE TO ROTATE 180°, AT 170° THE AFT WHEEL LOCK STRUTS RELEASE THE WHEELS, BUT ARE RETAINED TO THE LRV BY TETHERS
12. THE FWD CHASSIS IS RELEASED, BUT DOES NOT ROTATE DUE TO INTERFERENCE WITH LM STRUCTURE AT THIS TIME.
13. RIGHT BRAKED REEL IS OPERATED UNTIL LRV CENTER CHASSIS IS AT 73°
14. LRV CAM ROTATES STEEL LATCH ARM RELEASING CAM FROM SUPPORT ARM (DETAIL D)

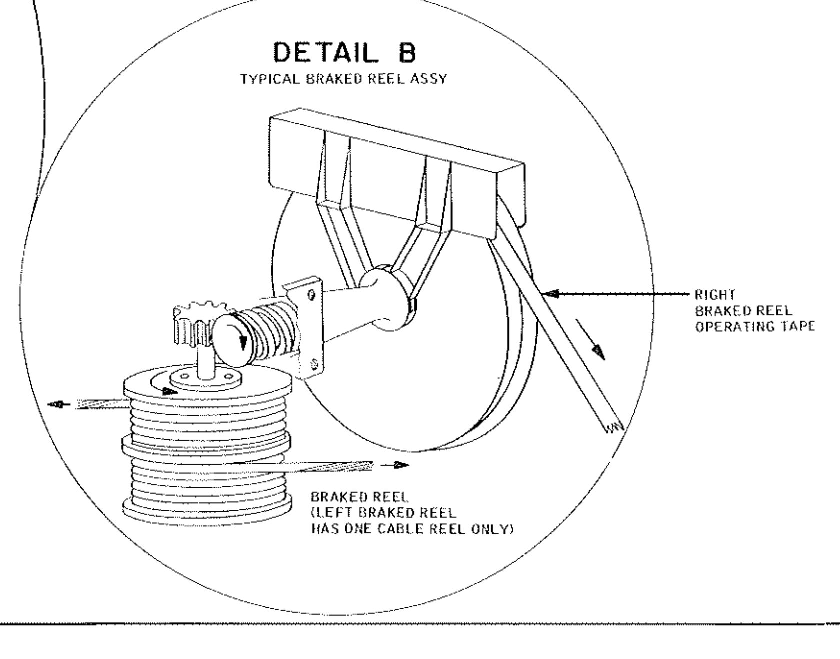
(CONTINUED ON SHEET 2)



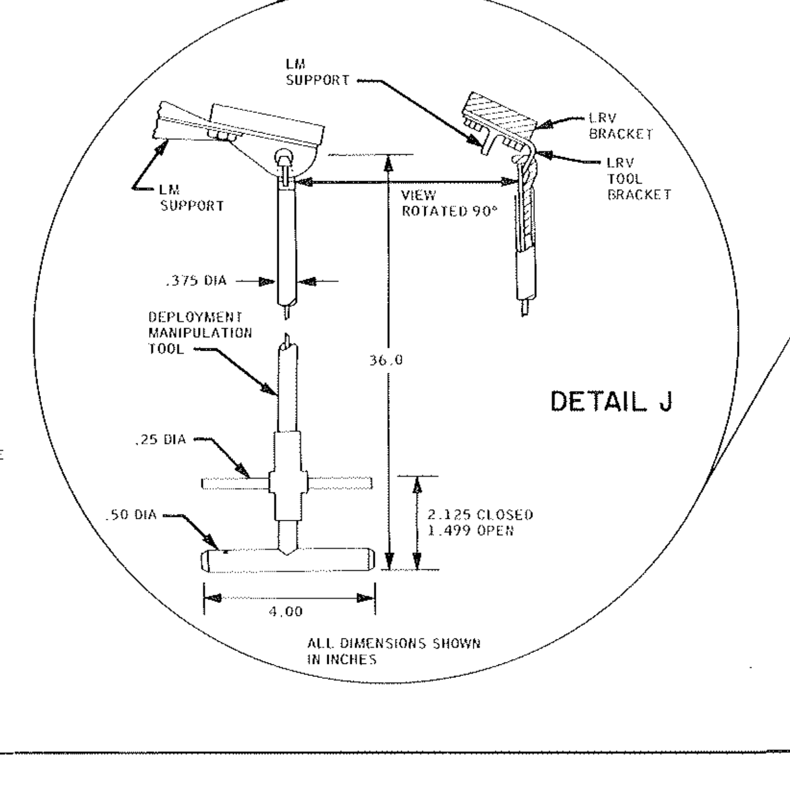
STRUCTURAL SUPPORT SYSTEM AND DEPLOYMENT HARDWARE



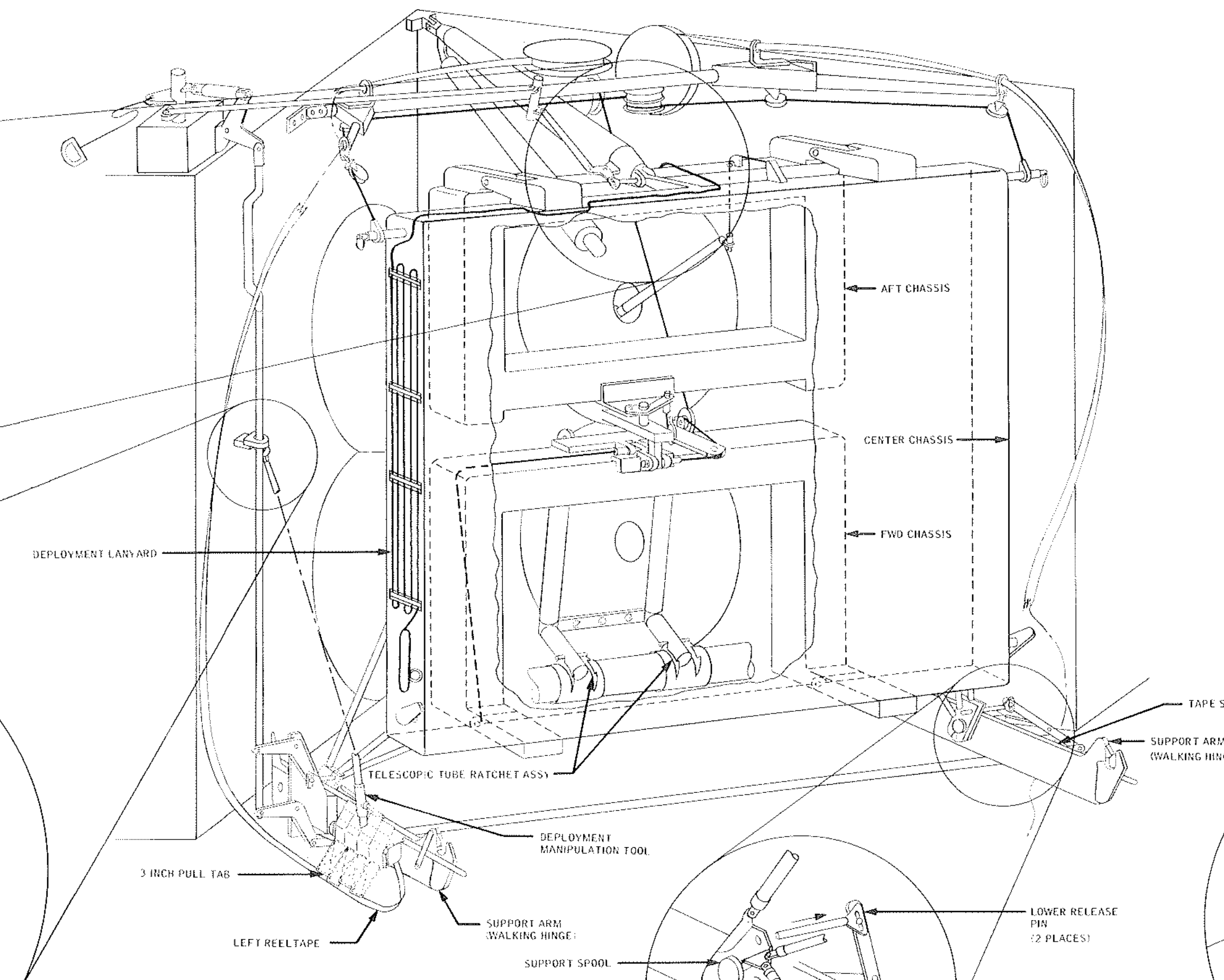
DETAIL A

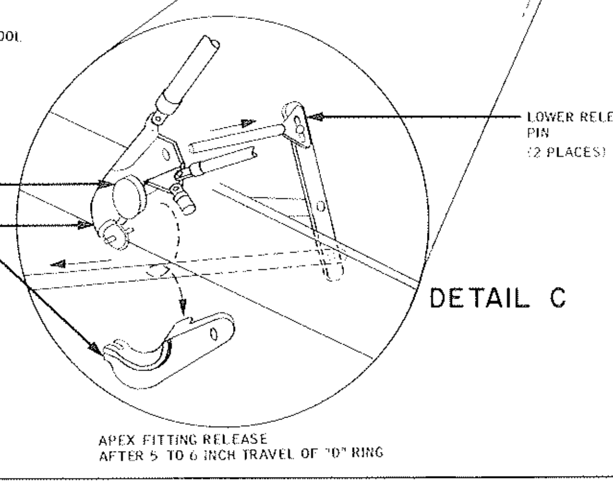


DETAIL B

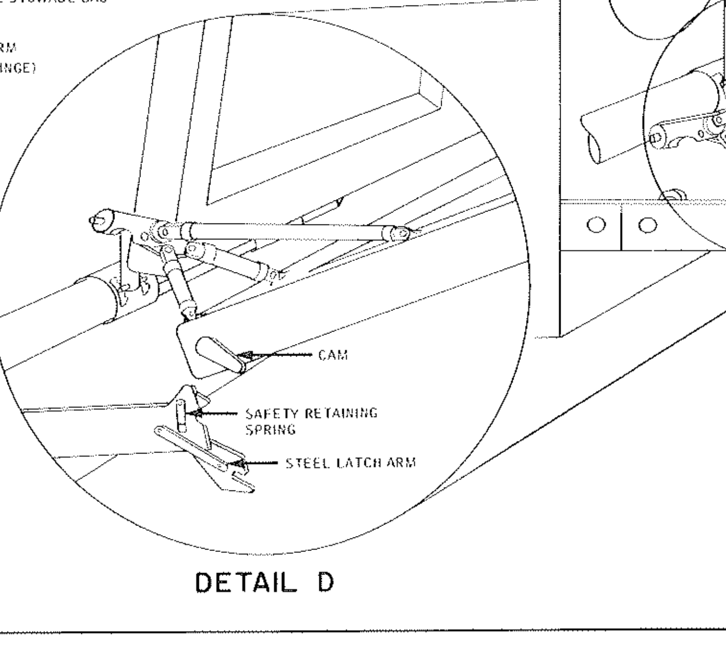


DETAIL J

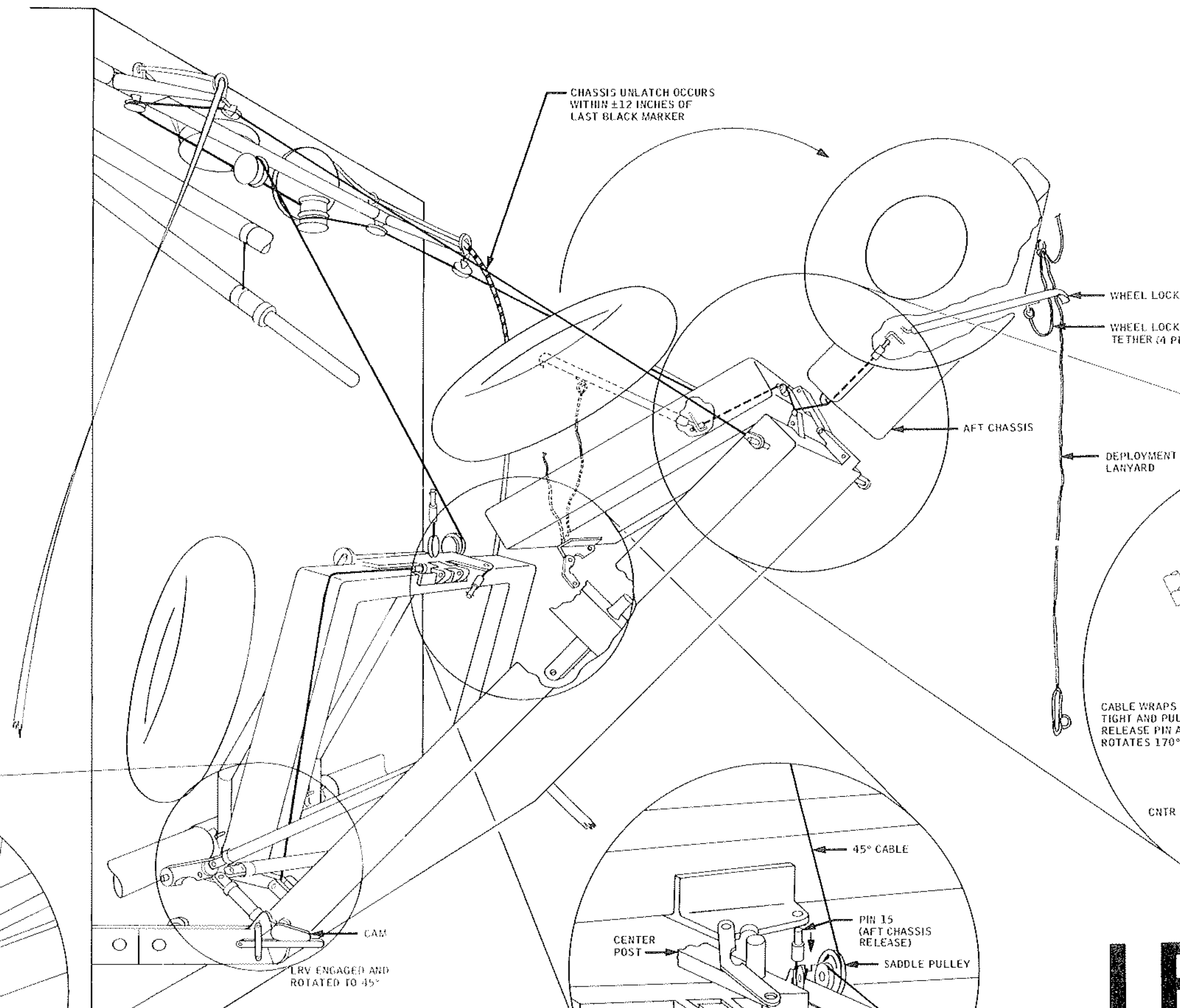


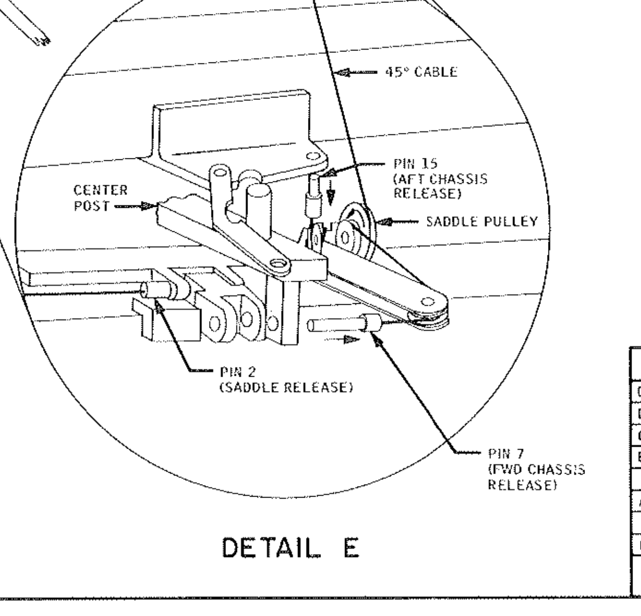


DETAIL C

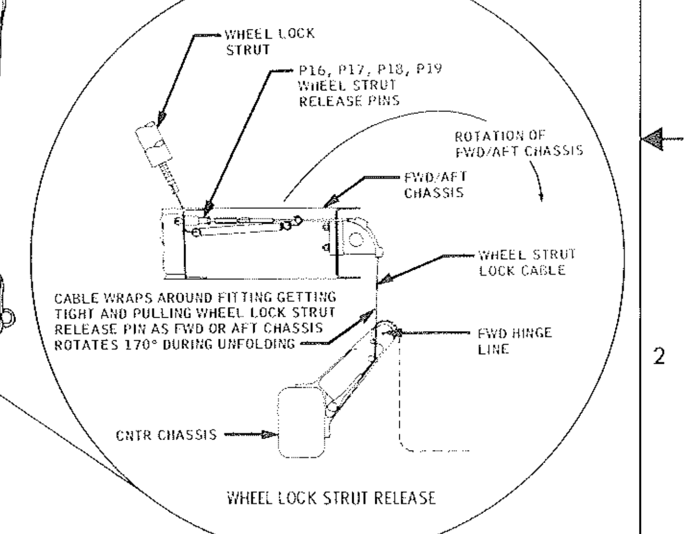


DETAIL D





DETAIL E



WHEEL LOCK STRUT RELEASE

DETAIL I

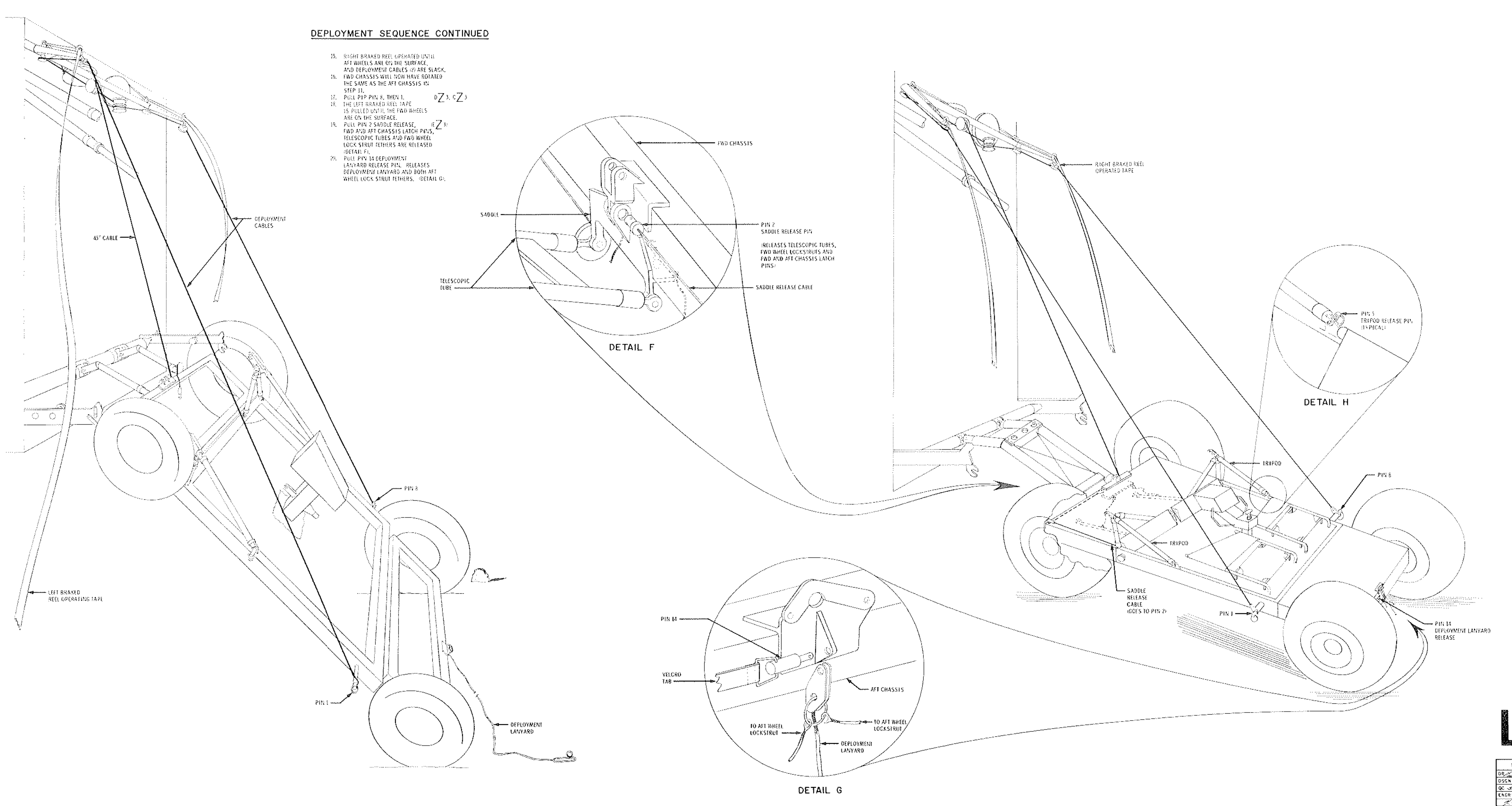
LRV SSE

SIGNATURES	DATE	
DR [signature]	4-14-71	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DSGN Martin Cohen	4-14-71	LRV MANUAL DEPLOYMENT MECHANISM (SPACE SUPPORT EQUIPMENT)
QC [signature]	4-14-71	
ENGR Harry Smith	4-15-71	
[signature]	4-15-71	
APP Donald R. Puddy	4-15-71	
FEC [signature]	4-14-71	

LRV	D_5	DWG NO 9.3
APOLLO 17		
85 X 22	PAGE 9-8	SHEET 1 OF 2

DEPLOYMENT SEQUENCE CONTINUED

15. RIGHT BRAKED REEL OPERATED UNTIL AFT WHEELS ARE ON THE SURFACE, AND DEPLOYMENT CABLES (2) ARE SLACK.
16. FWD CHASSIS WILL NOW HAVE ROTATED THE SAME AS THE AFT CHASSIS IN STEP 11.
17. PULL PIP PIN 8, THEN 1. DZ3, CZ3
18. THE LEFT BRAKED REEL TAPE IS PULLED UNTIL THE FWD WHEELS ARE ON THE SURFACE.
19. PULL PIN 2 SADDLE RELEASE, (EZ3) FWD AND AFT CHASSIS LATCH PINS, TELESCOPIC TUBES AND FWD WHEEL LOCK STRUT TETHERS ARE RELEASED (DETAIL F).
20. PULL PIN 14 DEPLOYMENT LANYARD RELEASE PIN. RELEASES DEPLOYMENT LANYARD AND BOTH AFT WHEEL LOCK STRUT TETHERS. (DETAIL G).



LRV SSE

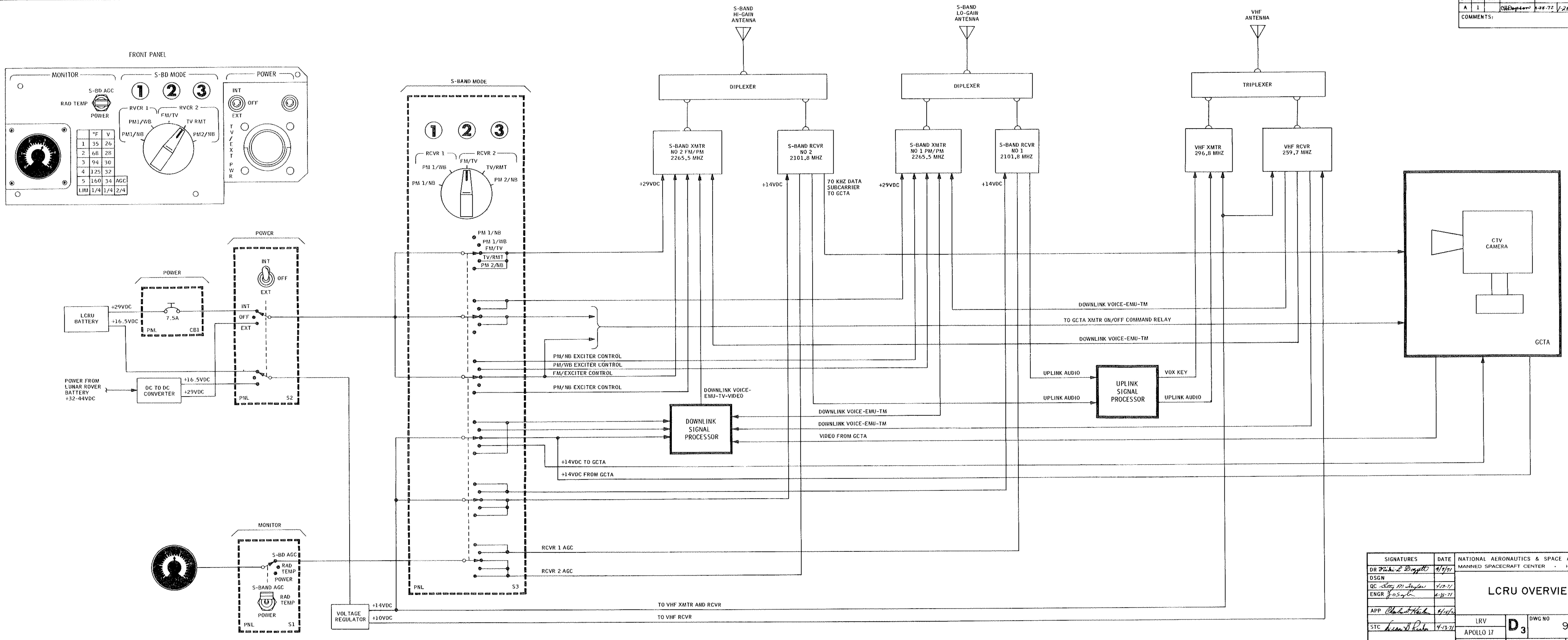
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER – HOUSTON, TEXAS

LRV MANUAL DEPLOYMENT MECHANISM (SPACE SUPPORT EQUIPMENT)

LRV | J1 | DWG NO 9.3 | SHEET 2 OF 2

LTR	PCN	DR	ENGR	DATE		APPROVAL
A	1		CHDopson	1-24-72	1-21-72	[illegible]

COMMENTS:



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS		
DR Nicki L. Doggett	4/9/71			
DSGN				
QC Betty M. Taylor	4-13-71	LCRU OVERVIEW		
ENGR Joseph	4-15-71			
APP Charles [illegible]	4/15/71			
STC [illegible]	4-13-71	LRV APOLLO 17	D3	DWG NO 9.4
		55.25 X 22	PAGE 9-10	SHEET 1 OF 1

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR	3-10-71	LCRU DETAILED
DSGN		
QC	4-5-71	
ENGR	4-15-71	
ENGR		
APP	4/15/71	LRV · APOLLO 17 · J_5 · DWG NO 9.5
APP		
STC	4-15-71	121 X 34 · PAGE 9-11 · SHEET 1 OF 1

LCRU
TCU
CTV
70 KHZ SUB-CARRIER FROM LCRU COMMAND
70 KHZ DEMODULATOR
BI-PHASE DEMODULATOR
COMMAND DATA
TIMING
DIGITAL DECODER
COMMAND DECODER ELECTRONICS
IRIS DRIVER
ZOOM DRIVER
PAN MOTOR DRIVER
TILT MOTOR DRIVE
MOTOR DRIVERS
PAN MOTOR
TILT MOTOR
IRIS MOTOR
ZOOM MOTOR
CTV LENS ASSEMBLY
IRIS 2 2.8 4 5.6 8 11 16 22
ZOOM 12.5 15 20 25 30 40 50 75
FM TRANSMITTER CONTROL TO LCRU
+29VDC
+29VDC FROM LCRU
POWER ON
POWER OFF
POWER SWITCH
TV POWER
ON
OFF
REMOTE
LUNAR COMMUNICATIONS RELAY UNIT
1.25 MHZ SUB-CARRIER ON/OFF CONTROL TO LCRU
+14 VDC FROM LCRU
SUB-CARRIER ON
SUB-CARRIER OFF
S/C MODE SELECTOR
HORIZONTAL LINE RATE
VOLTAGE PRE-REGULATOR
DC-DC CONVERTER
VOLTAGE REGULATOR
POWER SUPPLY
+12VDC
-12VDC
+5VDC
-5VDC
TO COMMAND DECODER ELECTRONICS
ALC AVERAGE
ALC PEAK
ALC MODE SELECTOR
VIDEO
TEST SIGNAL ADDER
TEST SIGNAL GENERATOR
TEST SIGNAL TIMING
LM POWER
+29VDC FROM LM
ALC
PEAK
AVERAGE
REGULATOR
DC-DC CONVERTER
+300VDC
+500VDC
-100VDC
TO SIT VIDICON ELECTRODE
SYNC GENERATOR
HORIZ RATE
DIVIDER ÷ 8
DIVIDER ÷ 75
DIVIDER ÷ 28
DIVIDER ÷ 4
1.007 MHZ OSCILLATOR
GATE
HORZ DRIVE HORZ SYNC
VERT DRIVE VERT SYNC
Φ SHIFT
MOTOR Φ GENERATOR
COLOR FLAG GENERATOR (LINE 18 TAG)
LINE 17 TAG
CTV TEMP -40 TO +200° F ANALOG
LENS
COLOR WHEEL
OPTICAL PICKUP
LIGHT EMITTER
SYNCHRONOUS MOTOR
SIT
VIDICON
HIGH VOLTAGE POWER SUPPLY
VERTICAL SYNC
HORIZONTAL SYNC
FOCUS REG
ALIGNMENT REG
BEAM CURRENT REG
HORIZONTAL DEFLECTION
VERTICAL DEFLECTION
MOTOR DRIVE
PREAMP
VIDEO AMPLIFIER
60 MVP-P
VIDEO AMP
1VP-P
AGC
DELAY
CLAMP
DIFF AMP
BLACK STRETCH
THRESHOLD (CORING)
WHITE CLIP
BLANKER
BLACK CLIP
SYNC, COLOR FLAG ADDER
LINE 18 TAG (5 TO 45 μ SEC)
DRIVER
VIDEO TO LM
COMMENTS:
SIGNATURES
DATE
DR Beverly Roberts 4-12-71
DSGN
QC 4-13-71
ENGR 4-15-71
APP 4-15-71
STC 4-13-71
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
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LRV
APOLLO 17
D3
DWG NO 9.6
68 X 22
PAGE 9-12
SHEET 1 OF 1

APOLLO

LRVSH

LUNAR ROVING VEHICLE SYSTEMS HANDBOOK

APOLLO 17

LRV-3

OCT 2, 1972

FCD
MSC
NASA